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A LIST OF THE ALEYRODIDAE OF THE ISLAND OF RÉUNION

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Abstract.—Collection data are given for 15 described and five undescribed species of Aleyrodidae and for six collections of early stage Aleyrodinae. Citations are given to 21 publications that contain references to the Aleyrodidae of Réunion. Parasites and/or predators of four species of Aleyrodidae are indicated.

This list of the Aleyrodidae of the Island of Réunion is the first to be published on the aleyrodid fauna of a Mascarene Island. The article lists 21 species of Aleyrodidae, six of which apparently are undescribed, and six collections of unidentified larvae, with collection data. The species belong in the Aleyrodinae except for one, indicated in the list, which is placed in the Aleurodicinae. Parasites and/or predators of four aleyrodid species are listed. The collections were made by J. Etienne except as noted, and the specimens are in the U.S. National Museum of Natural History, Washington, D.C.

The aleyrodids are reported from 31 plant genera belonging to 20 families and from several unidentified plants. Eleven genera and seven families are recorded, for the first time, as hosts of Aleyrodidae in Réunion. The botanical names appearing herein have been checked in Hortus Third (Staff of the L. H. Bailey Hortorium, Cornell University, 1976) and/or Index Kewensis and Supplements (various compilers, 1855–1974). Family names of plants are given only once, the first time a host plant is listed.

Literature citations are given for all the articles we have found that have scientific names of Aleyrodidae reported from Réunion.

ALEYRODIDAE OF RÉUNION

Acutaleyrodes palmae Takahashi.

Recorded by Takahashi (1960b) on *Acanthophoenix rubra* (Palmae), Saint-Philippe, XII-1925, R. Paulian. Re-recorded by Mound and Halsey (1978).

Aleurocanthus hibisci Corbett.

On *Hibiscus liliiflorus* (Malvaceae), Saint-Denis, 19-XI-1976.

On *Cassia siamea* (Leguminosae), Saint-Denis, 7-V-1978.

Eretmocerus sp. (Aphelinidae) is a parasite of *A. hibisci* in Réunion.

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Aleurodes trachoides Pack! (= Aleurotrachelus trachoides (Back)).

Recorded by Luziau (1953b) and by Plenet (1960b, 1965) on *Casuarina equisetifolia* (Casuarinaceae). Orian (1972) referred to Luziau's record but questioned the identification of *trachoides*. Mound and Halsey (1978) referred to Orian's report. We think it is unlikely that *trachoides* occurs in Réunion on *Casuarina*.

Aleuroplatus evodiae Takahashi.

Recorded by Takahashi (1960a) on *Evodia* sp. (Rutaceae), Plaine d' Affouches, V-1957, J. Bosser. Re-recorded by Mound and Halsey (1978).

Aleuroplatus subrotundus Takahashi.

Recorded by Takahashi (1960a) on *Eugenia Jambos* (= *Syzygium Jambos*) (Myrtaceae), Bois de Nèfles near Saint-Denis, V-1957, J. Bosser. Re-recorded by Mount and Halsey (1978).

Aleuroplatus sp. (undescribed).

On unidentified plant, Forêt de Bébour, 20-XI-1975.

Aleurothrixus floccosus (Maskell).

Recorded by Mound and Halsey (1978) without host plant or locality.

Recorded by Etienne (1978) and by Etienne and Vilardebó (1978) on *Citrus* sp. (Rutaceae); and by Etienne (1978) on *Calophyllum* sp. (Guttiferae), *Eugenia pimenta* (= *Pimenta dioica*) (Myrtaceae), and *Psidium cattleianum* (Myrtaceae).

On *Citrus* sp., Cambai, 25-III-1975, B. Aubert, from Y. Ben-Dov and 10-VII-1975, from J. Onillon; Tampon, 5-X-1976; Sainte-Anne, 28-X-1976; La Bretagne, 27-IX-1977.

On *Calophyllum* sp., La Possession, 9-XII-1976.

Accidentally introduced, *A. floccosus* was the most serious pest of citrus in Réunion before 1975. Predators belonging to the Coccinellidae, Chrysopidae, and Miridae did not maintain a low level population of the whitefly. In 1976 *Cales noacki* Howard (Aphelinidae) was introduced and within two years after its release, the *floccosus* population was reduced sufficiently to make chemical control of the aleyrodid unnecessary.

Aleurotrachelus pauliani Takahashi.

Recorded by Takahashi (1960b) on unidentified plant, Cilaos, XII-1955, R. Paulian. Re-recorded by Mound and Halsey (1978).

Aleurotrachelus reunionensis Takahashi.

Recorded by Takahashi (1960b) on unidentified plant, Cilaos, XII-1955, R. Paulian. Re-recorded by Mound and Halsey (1978).

Bemisia elliptica Takahashi.

Recorded by Takahashi (1960b) on unidentified plant, Cilaos, XII-1955, R. Paulian. Re-recorded by Mound and Halsey (1978).

Bemisia sp.

On *Manihot utilissima* (= *M. esculenta*) (Euphorbiaceae), Mouffia, 25-XI-1976.

Bemisia tabaci (Gennadius).

Recorded by Bouriquet (1938) as *Bemisia manihotis* Frappa ". . . au Jardin Colonial de St. Denis et au Piton St. Leu . . ." Recorded by Luziau (1953a) as *Bemisia maniotis*! Frappa on manioc.

Dialeurolonga simplex Takahashi.

Recorded by Etienne (1978) and by Etienne and Vilardebó (1978) on *Citrus* sp.

On *Citrus* sp., Entre-Deux, V-1972, H. D. Catling; Tampon, 5-X-1976, 10-X-

1976; Sainte-Anne, 21-X-1976, 28-X-1976; Gol-les-Hauts, 4-XI-1976; Saint-Philippe, 10-XI-1976; La Bretagne, 27-IX-1977.

On *Calophyllum* sp., Le Tremblet, 11-IX-1975.

Dialeurolonga sp. (undescribed).

On *Citrus* sp., Haut de Bras Panon, 25-III-1975, B. Aubert, from Y. Ben-Dov.

Neomaskellia bergii (Signoret).

Recorded by Guérin-Meneville (1868, 1869), by Signoret (1869), and by Bordage (1900) on sugarcane (Gramineae). Recorded by Williams and Mamet (1954, 1962) and by Plenet (1960a, 1965) on *Saccharum officinarum* (Gramineae).

On *Saccharum officinarum*, Petite-Ile, 2-XI-1976 and La Bretagne, 25-XI-1976.

On *Pennisetum purpureum* (Gramineae), La Bretagne, 16-XII-1976.

Stenaleyrodes vinsoni Takahashi (Aleurodicinae).

Recorded by Takahashi (1938) on palm (Palmae), Saint-Denis, X-1937, J. Vinson. Re-recorded by Mound and Halsey (1978). Recorded by Mamet (1952) as "fairly troublesome" on *Chrysalidocarpus lutescens* (Palmae), *Cocos nucifera* (Palmae), and *Oreodoxa regia* (=*Roystonea regia*) (Palmae), Saint-Denis, 19–21-VII-1951, J. R. Williams. Recorded by Plenet (1960b, 1965) as a parasite of *Aspidiotus destructor* Signoret (Diaspididae) on *Cocos nucifera*. We do not think this aleyrodid was a parasite of a diaspidid (Coccoidea), but that the two occurred together on *Cocos*.

On palm, Saint-Denis, 14-X-1963, J. G. Pointel, from G. Remaudière.

On *Chrysalidocarpus lutescens*, Saint-Denis, 4-XI-1976.

On *Cocos nucifera*, Saint-Denis, 7-XII-1976.

Clitostethus arcuatus (Rossi) (Coccinellidae) is a predator of *S. vinsoni* in Réunion.

Tetraleurodes sp. (undescribed).

On *Citrus* sp., Plaine des Palmistes, 2-X-1976.

Tetraleurodes sp. (undescribed).

On *Ocotea* sp. (Lauraceae), Les Makes, 23-II-1978.

Trialeurodes elaphoglossi Takahashi.

Recorded by Takahashi (1960a) as *Trialeurodes elaphroglossi*! on *Elaphroglossum*! sp. (Polypodiaceae), Plaine des Caffres, VI-1957, J. Bosser. Re-recorded by Mound and Halsey (1978).

Trialeurodes vaporariorum (Westwood).

Recorded by Etienne and Roura (1976) on *Sechium edule* (Cucurbitaceae), Cilaos; *Cucumis sativus* (Cucurbitaceceae), Saint-Pierre; *Curcubita pepo* (Cucurbitaceae), Saint-Pierre and Plate; *Gerbera* sp. (Compositae), La Bretagne; *Lycopersicon esculentum* (= *L. Lycopersicum*) (Solanaceae), Sainte-Marie; *Pelargonium capitatum* (Geraniaceae), Colimaçons and Tampon; *Phaseolus* sp. (Leguminosae), Colimaçons and La Bretagne.

On *Hibiscus* sp., La Bretagne, 16-IV-1975.

On *Pelargonium capitatum*, Les Colimaçons, 2-X-1975 and 28-X-1976, Trois Bassins, 7-XI-1976.

On *Lycopersicon esculentum* (= *L. Lycopersicum*), Saint-Louis, 1-XI-1975.

On *Phaseolus* sp., La Bretagne, 24-XI-1975 and Les Colimaçons, 28-X-1976.

On *Mussaenda arcuata* (Rubiaceae), Saint-Philippe, 11-XII-1975.

On yellow plate, Saint-Philippe, Forêt de la Mare Longue, 14-IV-1976.

On *Sechium edule*, Cirque de Cilaos, 29-XI-1976 and Cilaos, 26-I-1978.
On *Nasturtium officinale* (Cruciferae), Cirque de Cilaos, 29-XI-1976.
On *Siegesbeckia orientalis* (Compositae), Entre-Deux, 23-VI-1977.

T. vaporariorum, a polyphagous species, was first collected in Réunion in January 1975 (Etienne and Roura, 1976). It became established and was soon recognized as a serious pest of horticultural crops. *Encarsia formosa* Gahan and *E. tricolor* Foerster (Aphelinidae) were introduced from France in 1977 to control the whitefly. The recovery of *E. formosa* in 1980 at Les Colimaçons, three years after its release, indicates that the parasite was established on the island. At the present time, however, we do not know whether *vaporariorum* is being efficiently controlled by *E. formosa*.

Aleyrodinae (undescribed genus and species).
On unidentified plant, Forêt de Bébour, 20-XI-1975.

Aleyrodinae (immature).
On *Tambourissa* sp. (Monimiaceae), Forêt de Bébour, 13-XI-1975.
On *Nuxia verticilla* (Loganiaceae), Forêt de Bébour, 20-XI-1975.
On *Ficus mauritiana* (Moraceae), Route de Salazie, near Pont de l'Escalier, 10-XII-1975.
On *Takamaka inophyllum* (Guttiferae), Saint-Philippe, 14-IV-1976.
On *Citrus* sp., Entre-Deux 25-III-1975, B. Aubert from Y. Ben-Dov; Plaine des Palmistes, 2-X-1976.

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BIOLOGY AND IMMATURE STAGES OF *THECESTERNUS HIRSUTUS* PIERCE (COLEOPTERA, CURCULIONIDAE) IN NORTH-EASTERN MEXICO

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Abstract.—*Thecesternus hirsutus* Pierce (Thecesterninae) was studied in northeastern Mexico as a biocontrol agent against *Parthenium hysterophorus* L. (Asteraceae), an introduced weed pest in Australia, and field and laboratory observations on the previously little-known biology of this weevil are reported. There is one generation per year. The larval stage overwinters. Larvae hatch from eggs laid in the soil surface, burrow down to the host's roots, on which they feed externally, causing a gall-like swelling at each feeding-site, and construct earthen cells around themselves and the feeding-sites. Although its host range is highly specific, including only a few closely related species of *Parthenium, T. hirsutus* does not seem promising as a biocontrol agent because larval feeding does not cause significant damage to the plants. Larvae and pupae are described for the first time for the Thecesterninae and larval morphology clearly places this group in the section Phanerognatha of the Curculionidae.

The Thecesterninae are a small North American subfamily of large weevils whose biology has been little studied and whose immature stages have never been reported. The subfamily contains one genus, *Thecesternus*, with seven species (O'Brien and Wibmer, 1982), and the adults are characterized structurally by their unlobed tarsi, the short, broad rostrum which fits into a deep emargination in the prothorax, and the triangular form of the prosternum which lies posterior to this emargination (Kissinger, 1964). Blatchley and Leng (1916) quoted a report by [C. V.] Riley (no reference cited) of the adults cutting off grape blossoms, while Kissinger (loc. cit.) states that they are to be found under stones and dried cow dung. Apart from these references there seems to be virtually no published information on the biology of the group.

From 1978 to 1983 one of us (McClay) was engaged in studies of the natural enemies of the annual weed *Parthenium hysterophorus* L. (Asteraceae) in northeastern Mexico on behalf of the Department of Lands of Queensland, Australia. This plant, native to the neotropics, was introduced into Australia in the 1950's, and since 1973 has become a serious problem in cattle-raising areas of central Queensland (Haseler, 1976). The studies in Mexico were aimed at identifying potential biocontrol agents for use against it in Queensland, and were carried out from a base at Monterrey, Nuevo Leon.

During these studies, large curculionid larvae were found feeding externally on the roots of *P. hysterophorus.* Adults reared from these larvae were identified by D. R. Whitehead of the Systematic Entomology Laboratory, IIBIII, USDA, in Washington, D.C. as *T. hirsutus* Pierce. While this species was being evaluated as a possible biocontrol agent for *P. hysterophorus,* observations were made of its life-history, habits and host-specificity, and larvae and pupae were collected for detailed morphological study.

Collections were made at a number of sites in the vicinity of Monterrey. *Thecesternus hirsutus* was found to be locally common, favoring dry, stony, well-drained sites subject to little disturbance. It was collected mainly as larvae, which when collected partly-grown could be reared through to pupation in the laboratory on an artificial diet (Harley and Willson, 1968). Adults were rarely found in the field.

Although the evaluation suggested that *T. hirsutus* was not a promising biocontrol agent for *P. hysterophorus,* material has been sent for further study to the Department of Lands laboratories at Sherwood, Queensland. If it is confirmed to be sufficiently host-specific, this species may eventually be released onto infestations of *P. hysterophorus* in Queensland.

The descriptions of the immature stages presented here will help future investigators to identify larvae and pupae of this genus and to establish the correct systematic position of the subfamily Thecesterninae within the Curculionidae.

LIFE HISTORY

Information on the life history was derived mainly from observations on weevils kept in an open insectary on potted plants of *P. hysterophorus* under ambient conditions.

The eggs are laid in the soil surface either at the base of the host plant or within the area of the root system, and covered with a few mm of soil. If oviposition is not completed, the site appears as a small conical pit in the soil surface. Females observed ovipositing adopted a characteristic "head-up" position with the tip of the abdomen inserted in the soil surface and being moved back and forth to excavate the oviposition hole. The egg is smooth and pale yellow, ovoid, approximately 1.40 × 1.04 mm in size. Owing to the concealed oviposition site, the duration of the egg stage is not known exactly.

The newly-hatched larva burrows down into the soil from the oviposition site and begins to feed externally on either a tap-root or a lateral root. A gall-like swelling soon begins to form at the feeding site, resulting from a proliferation of the cortical tissue of the root. The stele is little affected by the gall formation or the feeding of the larva. As the larva grows it forms around itself an earthen cell, which is attached around the edge of the feeding site on the gall. At first the cell is fairly fragile but later becomes reinforced by an interior layer of a dark brown papery material that gives it considerable toughness. Larvae feeding on artificial diet in the laboratory were observed taking drops of excreta from the anus into the mouthparts and spreading them on the surface of the diet block. This behavior is probably responsible under natural conditions for the formation of the reinforcing layer of the feeding cell.

The gall may be as large as 10 mm in diameter, and in the field up to 12 nearly-mature larvae have been found feeding on the roots of a single plant. Their feeding does not seem to have any significant detrimental effect on the growth of the plant. The normal duration of the larval stage in the field appears to be about 6 months. Larvae are often found on the roots of *Parthenium* plants growing several m from their nearest neighbors of the same species, indicating that the adults, although flightless, have a well-developed searching ability for the host plant.

Pupation takes place in the feeding cell. The duration of the pupal stage of individuals that were fed on the laboratory diet varied from 16 to 20 days. Detailed morphological descriptions of the larva and pupa are given below.

After eclosion the teneral adult remains in the cell for several days to harden up before cutting a hole in the cell and tunnelling up to the soil surface. Adults which emerged in the laboratory did not begin to feed until 14 to 24 days after eclosion. When maintained on potted plants of *P. hysterophorus*, they fed somewhat sparingly on the foliage, cutting pieces out of the edges of the leaves. Their mottled gray coloration provides a very effective disguise on the soil surface. Feeding, mating, oviposition and locomotion were all observed during daylight, but on some occasions the weevils were inactive during the day in cracks in the soil or in the corners of the cage. The adults are long-lived, some surviving for at least 10 months.

PHENOLOGY

From January to December of 1982, a site near the village of Dr. Gonzalez, about 54 km north-east of Monterrey, was visited at approximately monthly intervals in order to determine the seasonal occurrence of the different stages of the life-cycle. From these observations it is apparent that *T. hirsutus* has a mainly univoltine life-cycle, with the main period of oviposition occurring in September when the late summer rains lead to a flush of growth of *P. hysterophorus*. The larvae then feed over the autumn and early winter, ceasing to feed when they reach full development some time between December and February. Pupation occurs in early April and the adults emerge in April or May to feed over the summer and oviposit in September. The finding of a few early-instar larvae from May onwards, and of some pupae in September and October, suggests that some adults may oviposit in the spring, giving rise to a partial second generation over the summer. The timing of oviposition is probably influenced by the availability of the host plant in a suitable condition. In the insectary, adults which had emerged the previous year oviposited from February onwards.

HOST-SPECIFICITY

Larvae were found in the field on roots of both *P. hysterophorus* and *P. confertum* DC. One larva found on *P. bipinnatifidum* Villanova near San Luis Potosi, SLP, was similar to those found on *P. hysterophorus* and *P. confertum*, but was not reared to the adult stage. Examination of the roots of other Asteraceae growing in the vicinity of *P. hysterophorus*, mainly at the Dr. Gonzalez site showed no larvae feeding on *Melampodium cinereum* DC, *Viguiera dentata* (Cav.) Spreng., *Ambrosia confertiflora* DC, *Dyssodia micropoides* (DC) Loes., *D. pentachaeta* (DC) Robins or *Chaetopappa* sp.

Host-specificity tests were also carried out in the insectary, in multiple-choice cages in which potted plants of *P. hysterophorus* and other species of Asteraceae were exposed to the adult weevils. The design of the test cages was such that the weevils could move freely from one plant to another and had access to both the plants and the soil surface in the pots. In this way both feeding and oviposition preferences could be studied. Five to seven weeks after setting up a test, the roots of all test plants were carefully cleaned of soil and checked for the presence of larvae. The other test plants used were *P. argentatum* Gray (the guayule rubber plant), *Helianthus annuus* L., *Ambrosia confertiflora* DC, *Bidens pilosa* L., *Xanthium* sp., *Lactuca sativa* L., *Cichorium intybus* L., and ornamental cultivars of coreopsis, zinnia and dahlia.

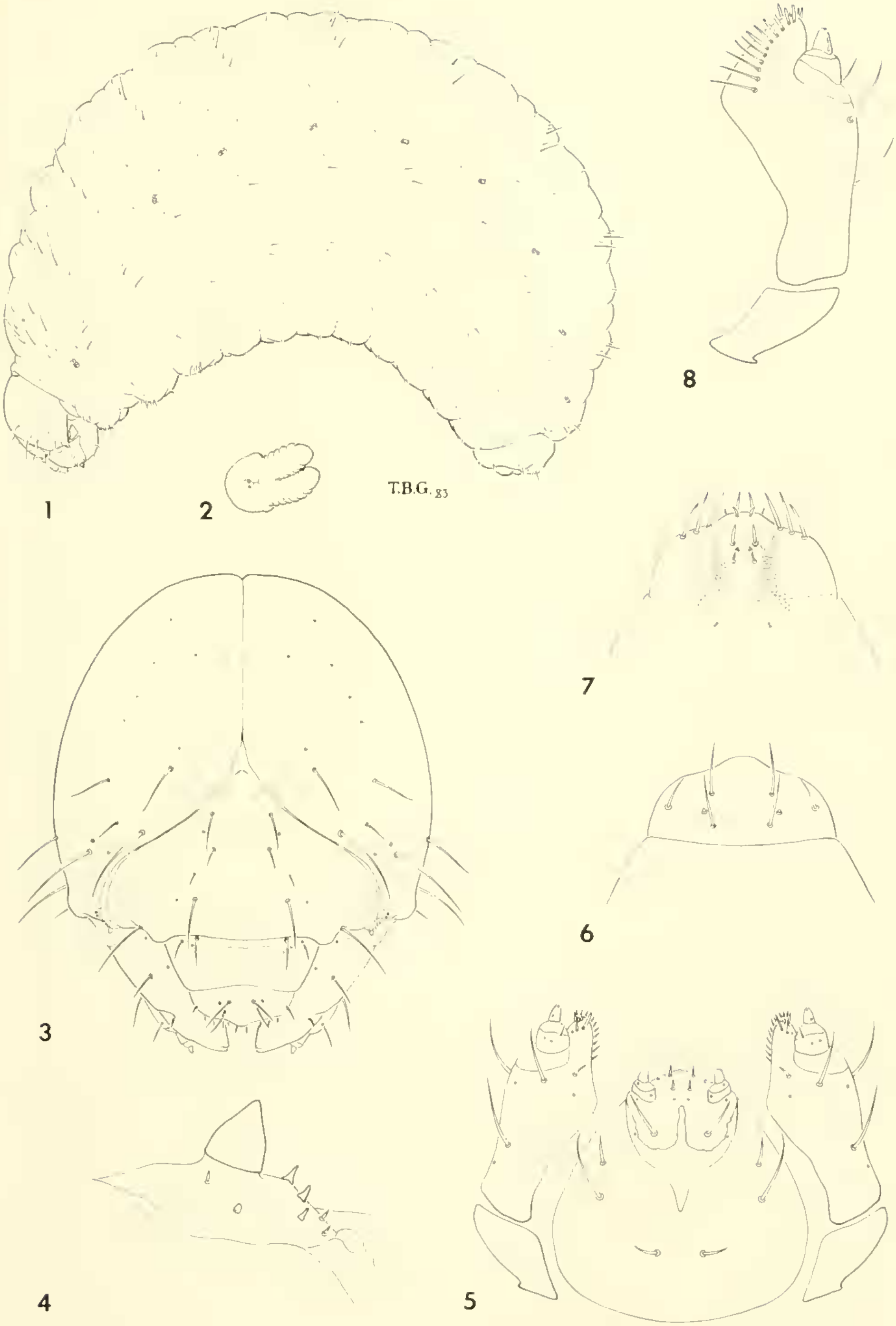
In these tests extensive feeding occurred on foliage of *P. hysterophorus*, while feeding was zero or negligible on all other test plants. Oviposition behaviour was seen frequently in the pots containing *P. hysterophorus*, but was never observed in those containing other test plants. Examination of the roots showed a mean of 9.7 larvae per plant of *P. hysterophorus* (range 0–24), while none were found on the roots of any other test plant.

Descriptions of Immature Stages

Larva.—The following description is based upon a series of 10 mature (final instar) larvae, of which 3 were dissected, collected at Garza Garcia, N.L., Mexico, Nov. 10, 1981, on roots of *P. confertum* by A. S. McClay and H. Miranda. Unless noted otherwise, the terminology used follows that of Anderson (1947).

Body: Stout, C-shaped, tapered at both ends (Fig. 1). Maximum length of entire specimens: 10.62 mm. Body white, with pale brown or unpigmented setae and tiny unpigmented asperities.

Head (Figs. 3–8): Convex dorsally, unretracted, slightly longer than wide; width of 8 measured: 1.40–1.60, mean 1.49 mm. Epicranium and frons light orange-brown, darkest dorsolaterally and around mouthframe. Epicranial suture slightly more than half length of epicranium. Five pairs of dorsal epicranial setae (des) present; des 3 and 5 longest, more than twice the length of des 4. Three pairs of dorsal epicranial sensilla present. Four pairs of minute posterior epicranial setae present. Two pairs of lateral epicranial setae present, subequal in length. Frontal sutures distinct, slightly sinuate, not reaching articulating membrane of mandible at anterior extremities. Frons with 5 pairs of setae (fs) and 2 pairs of sensilla; fs 4 and 5 subequal and distinctly longer than fs 1, 2, and 3. Endocarinal line distinct for approximately ⅓ length of frons. Two pairs of ventral epicranial setae present, subequal in length. Anterior ocellus present, its lens flat and its pigment divided into 2 equal spots; posterior ocellus vaguely indicated by a small subcutaneous pigment spot. Clypeus with 2 pairs of moderately long setae and 1 pair of basal sensilla. Labrum with 3 pairs of setae (lms) of which the inner 2 pairs (lms 1 and 2) are subequal, longer than lms 3, and with 2 basal sensilla but no median sensillum. Maxilla bearing 1 dorsal and 2 ventral setae on the stipes, a row of 10 or 11 dorsal malar setae, a group of 5 ventral malar setae of which 2 are short, 3 subequal to dorsal malar setae, and 4 ventral sensilla. Maxillary palpus of 2 articles, the first distinctly larger than the second and bearing 1 short ventral seta. Dorsal surface of maxilla partly covered with rows of microspicules. Premental sclerite of labrum trident-shaped with a pointed posteromedian process and an elongate anteromedian process. Labial palpi of 2 articles, the first distinctly broader than the second. Ligula bearing 2 pairs of short setae and 1 pair of rod-like sensilla. Three pairs of postmental setae (pms) present, of which pms 1 are more



Figs. 1–8. *Thecesternus hirsutus*, larva. 1, Entire larva, lateral view. 2, Abdominal spiracle. 3, Head, front view. 4, Antenna, dorsal view. 5, Labium and maxillae, ventral view. 6, Labrum, dorsal view. 7, Epipharynx, ventral view. 8, Right maxilla, dorsal view.

closely spaced than pms 2 or pms 3. Premental setae shorter than pms 2, subequal to pms 1 and 3. Hypopharyngeal bracon present, with a pair of pigmented spots near the center. Epipharynx with 3 pairs of anterolateral setae, 6 anteromedian setae, and 2 pairs of median setae (spines of Anderson, 1947), of which the anterior pair are longest. Labral rods (tormae) dark, elongate, slightly convergent posteriorly. Two pairs of sensilla clusters present on epipharynx; anterior pair, of 3 sensilla per cluster, posterior to 1st pair of median setae; posterior pair, of 2 sensilla per cluster, located posterior to labral rods. Asperities of epipharynx condensed into 2 paramedian stripes which converge anteriorly. Antenna a single membranous basal article bearing a subconical accessory sensory appendage (sensory cone) and 7 smaller processes. Mandibles stout, bifid at tips, orange-brown in basal ⅔, becoming dark brown at tips. Mandibular seta 1 more than twice the length of 2.

Thorax (Fig. 1): Pronotum lightly pigmented, bearing 11 setae on each side of midline. Spiracle bicameral; air tubes oriented dorsally, approximately as long as diameter of peritreme. Pleura bearing 2 setae on prothorax, 1 seta on meso- and meta-thorax. Alar areas both with 1 seta. Spiracular area of meso- and meta-thorax with 1 long and 1 short seta. Epipleura with 1 seta. Pedal areas with 8 setae, of which 3 are longer than the rest and 1 is minute. Sternal setae of medium length. Prodorsal folds of meso- and meta-thorax with 1 pair of median dorsal setae and 2 pairs of minute lateral setae. Postdorsal folds of meso- and meta-thorax with 4 pairs of setae, of which the second pair are short, the rest moderately long.

Abdomen (Figs. 1, 2): Eight pairs of lightly pigmented bicameral spiracles present, located laterally, with air tubes oriented posterodorsally. Segments 1–7 with 3 dorsal folds (folds II–IV) plus a small auxiliary fold behind fold IV; fold I developed laterally on segments 2–7. Prodorsal folds on segments 1–7 with 1 pair of dorsal setae and 1 pair of minute lateral setae. Five pairs of postdorsal setae (pds) present on segments 1–8, pds 1, 2 and 4 short, 3 and 5 long. Three pairs of pds on segment 9, the middle seta long, the others short. Epipleura and pleura on segments 1–8 with 2 setae of which 1 is short, the other of medium length. One short pedal seta and 2 pairs of short eusternal setae present on segments 1–9. Sternellum absent on all segments. Anus terminal, surrounded by 4 distinct lobes, the 2 lateral lobes bearing 1 short and 1 minute seta.

Alimentary canal (Figs. 9, 10): Terminology from May (1977): Proventriculus distinct but not expanded. Five or 6 large subglobular mycetomes encircling the constriction marking the cardiac valve. Anterior ventriculus large, deeply folded transversely at regular intervals. Posterior ventriculus with an anterior transverse twist followed by a longitudinal coil, on which the gastric caeca are arranged in an irregular row of 6 on each side. Six Malpighian tubules present, grouped 2 and 4 at origin, reinserted into a moderately developed cryptonephridium on the hindgut. Rectal bracon marked by an external constriction but membranous and difficult to discern.

No significant difference (other than size) was observed between the mature larvae described here and a series of 5 larvae (same collection data) that were clearly in an earlier instar, but no 1st instar larvae were available for study. Thus, it may be possible to identify most larvae of this species with the aid of the description and illustrations provided here, but if the 1st instar larva differs from later instars, as it does in some weevil genera, it may be difficult to identify.

Pupa.—The following description is based upon 4 pupae, of which 3 were reared from larvae collected at Dr. Gonzalez on Jan. 12, 1982, and 1 field collected at the same site between August and October, 1982. The terminology used here follows Burke (1968).

Body (Figs. 11, 12): Robust in form, white, with brown attenuate setae arising from tubercles of varying height. Length of 4 specimens: 8.72–11.62, mean 9.94 mm.

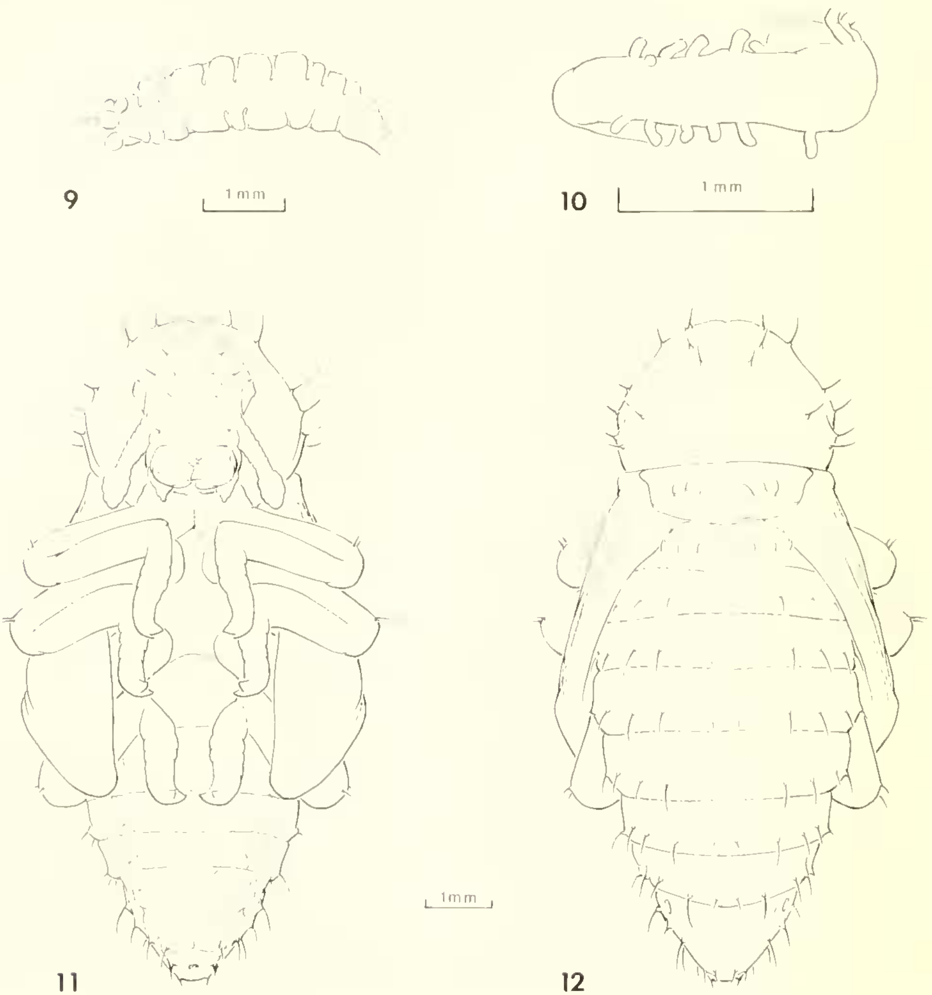
Head (Fig. 11): Convex dorsally, with impressed median ecdysial line. Rostrum very short, stout, untapered. Antennae thick, inserted at base of rostrum. Eyes not visible externally. Mandibles very stout, convex, 2-toothed, bearing 1 short seta. One pair of frontal setae, 3 pairs of supraorbital setae (1 pair short), 3–4 pairs of basirostral setae, and 3 pairs of distirostral setae present. Some tiny auxillary setae sometimes present on the rostrum.

Thorax (Figs. 11, 12): Prothorax slightly broader than long, convex dorsally and laterally; setae moderately long and slightly curved, borne on tubercles of moderate height, including 2 pairs of widely separated anteromedian setae, 2 pairs of posteromedian setae slightly anterior to middle of pronotum, 3 pairs of anterolateral setae, and 2 pairs of posterolateral setae. Ocular lobes well developed. Three pairs of mesonotal and metanotal setae present. No anteronotal setae present on meso- or metanotum. Elytral pads thick, convex, and distinctly striate externally, apices nearly reaching tips of hind femora. Hindwing pads very short, hidden by elytral pads. Forecoxae subglobose, approximate, concealing most of prosternum. Midcoxae separated by a distinctly protuberant mesosternum. Hindcoxae widely separated by the metasternum.

Abdomen (Figs. 11, 12): Convex dorsally, slightly swollen through middle segments and slightly wider at that point than broadest width of prothorax. Segments 1–7 each bearing 4 pairs of discotergal setae, of which the innermost pair are short, and 1 pair of laterotergal setae, all of which increase progressively in length and tubercle height posteriorly, becoming prominent on segments 5–7. Eighth segment bearing 1 pair of discotergal and 1 pair of laterotergal setae on prominent tubercles. Anal segment bearing 2 pairs of setae of which 1 pair arise from tips of short, curved posterior processes. Two pairs of very short laterosternal setae present on all but the anal segment. Spiracles nearly round to oval, distinct on segments 1–7. Sternopleural area longitudinally wrinkled on all segments. Sexes are separable, females having a distinct pair of lobes anterior to the anus, but males with a single plate bearing 4 short setae in that area.

DISCUSSION

The life cycle of *T. hirsutus* is well adapted to that of its host, *P. hysterophorus,* an opportunistic annual plant growing in an area of low and very seasonal rainfall. Where this insect was studied in Mexico, periods of highest rainfall occur on average in June and September, and each such period leads to a flush of growth of the plant. Adults emerging in early summer can thus usually build up reserves by feeding on the plants of the first flush, enabling them to survive until the plants of the second flush are available for oviposition. Larvae then develop on the roots



Figs. 9–12. *Thecesternus hirsutus.* 9–10, Larva, alimentary canal. 9, Proventriculus and anterior ventriculus, with their juncture marked by rounded mycetomes. 10, Posterior ventriculus, ventral view, with gastric caecae attached laterally. 11–12, Pupa. 11, Ventral view. 12, Dorsal view.

of these plants and, by the time plant growth ceases due to the cooler, dryer winter conditions, many of these will have developed sufficiently to enable them to pupate the following spring. The life cycle seems sufficiently flexible to allow a summer generation to occur if plants are available for oviposition.

Both the field and insectary observations indicate a high degree of host-specificity, feeding and larval development being restricted among the Asteraceae to *P. hysterophorus, P. confertum* and probably *P. bipinnatifidum.* These species are closely related, being grouped by Rollins (1953) in the section *Argyrochaeta* of the genus *Parthenium,* and they resemble each other closely in their general morphology. The gall-forming response of the roots to larval feeding is indicative of a close biochemical or physiological adaptation of this insect to its host, and is thus further evidence of specificity.

Thecesternus hirsutus does not cause serious damage to its host plant, and does not appear to be a promising biocontrol agent. Defoliation caused by the adults is light, and the fact that larval feeding is confined to the cortical tissue of the root means that it is unlikely to affect the plant's water uptake. However, its host specificity seems to be such that it could be released without causing damage to other plants.

No comparison of the larvae of *T. hirsutus* with those of other weevil genera will be attempted here, except to note that the incomplete frontal sutures, elongate sensory appendage of the antenna, and 3 distinct dorsal folds in typical abdominal segments clearly place this larva in the Phanerognatha as defined by van Emden (1952). However, it seems possible that further comparison of this larva with those of other weevils may help to establish the phylogenetic position of the genus *Thecesternus* to a greater extent than has been possible on the basis of adult specimens alone.

Acknowledgments

The biological observations on *T. hirsutus* were made by one of us (McClay) while employed by the Commonwealth Institute of Biological Control for studies of the natural enemies of *P. hysterophorus* in Mexico, funded by the Queensland Department of Lands. We are grateful to Dieter Enkerlin and the Instituto Tecnologico y de Estudios Superiores de Monterrey for providing facilities for this work, to D. R. Whitehead for the identification of *T. hirsutus*, to C. W. O'Brien for information on the genus *Thecesternus*, and to Hugo J. Miranda for technical assistance. We also thank T. Britt Griswold for his painstaking preparation of the illustrations. R. D. Gordon and E. W. Baker, Systematic Entomology Laboratory, USDA, and W. E. Clark, Auburn University, kindly reviewed and made helpful comments on the manuscript.

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SITONA LINEATUS (L.), THE PEA LEAF WEEVIL: FIRST RECORDS IN EASTERN NORTH AMERICA (COLEOPTERA: CURCULIONIDAE)

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Abstract.—The pea leaf weevil, *Sitona lineatus* (L.), a common pest of legumes in Europe, has been known from the Pacific Northwest (British Columbia, California, Idaho, Oregon, and Washington) since the mid 1930's. Recent collections from Virginia (Cheriton, Northampton Co. and Newport News) indicate that *S. lineatus* is established in eastern North America. North American interception records, host plants, economic importance, seasonal history, and habits are summarized for populations in Europe and the Pacific Northwest. An adult diagnosis and habitus allow separation of *S. lineatus* from the clover root curculio, *S. hispidulus* (F.), and other *Sitona* species known to occur in eastern North America.

Sitona lineatus (L.), a well-known pest of leguminous crops, is widely distributed through Europe (including the British Isles) and northern Africa (Morocco). In North America it is known from the Pacific Northwest. It was first detected in North America in 1936 when specimens were taken under codling moth bands at Royal Oak near Victoria, Vancouver Island, British Columbia (Downes, 1938). *S. lineatus* is now widespread in the coastal regions west of the Cascade mountain range in Oregon (Willamette River Valley) and Washington, and reaches the western end of the Fraser River Valley in British Columbia (Prescott and Reeher, 1961); it also occurs in central and northern California and northern Idaho (see map in U.S. Dept. Agric., 1970:58).

We provide here the first records of this introduced weevil in eastern North America (Virginia); review North American interception data for the species; summarize what is known of its food plants, habits, and seasonal history; and give characters for separating it from native and introduced species of *Sitona* occurring in eastern North America.

Detection.—A recent collecting trip by the authors to the Tidewater area and the Eastern Shore of Virginia produced the first confirmed records of the pea leaf weevil, *S. lineatus* (L.), in eastern North America. Specimens were swept from vegetation along railroad tracks at two sites in coastal Virginia: Northampton County, Cheriton, 26 May 1984, E. R. Hoebeke and A. G. Wheeler, Jr., colls.; Newport News, 26 May 1984, ERH and AGW. On a second trip to the Cheriton site, on 2 June 1984, AGW collected 74 specimens from hairy vetch (*Vicia villosa* Roth).

Interception records.—Each year from 1940 to 1963, specimens of *S. lineatus* were intercepted at ports of entry along the eastern seaboard. These records are from List of Intercepted Plant Pests, 1940–1963, compiled by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine programs. Most specimens apparently were associated with cut flowers originating from the Netherlands, Denmark, England, Germany, and Bermuda, and destined for New York, New Jersey, Pennsylvania, and Massachusetts.

The interception records from Bermuda are of particular interest. If *S. lineatus* is established in Bermuda (as the interception data would suggest), this then would be a likely source area of immigration into the mid-Atlantic states, perhaps more so than Europe or the West Coast. The field sites where we collected specimens (railroad right-of-ways and yards) at Cheriton and Newport News are near the expansive naval facilities of the Norfolk area. Reed (1964) listed several exotic weeds of European and South American origin that have been introduced with commerce to the port of Newport News. D. R. Whitehead (Systematic Entomology Laboratory, USDA, Washington, DC) has suggested that the Norfolk area, because of its naval facilities and proximity to Bermuda, might be a plausible (and relatively recent) focus of infestation (*in litt.*).

Host plants and damage.—Plants of the family Fabaceae (= Leguminosae) are the primary hosts of adult *S. lineatus* and represent the sole food source for the larvae. In the Pacific Northwest, the principal host plants are peas and vetch (Prescott and Reeher, 1961). Adults, however, also will cause severe feeding injury to alfalfa (*Medicago sativa* L.) and red clover (*Trifolium pratense* L.). In Great Britain, the food plants include peas, broadbeans, alfalfa, black medic (*Medicago lupulina* L.), all species of clover, tare (*Vicia sativa* L.), and wild vetches (*Vicia* spp.) (Jackson, 1920). When the principal leguminous food plant is in limited abundance, adults may feed on plants in various families (see Prescott and Reeher, 1961).

Adult feeding damage is characteristic, consisting of subcircular or U-shaped notches in the leaf margins, cut in close sequence and producing a scalloped effect (Prescott and Reeher, 1961). Severe ragging of the leaves or complete defoliation can occur in heavy infestations. Although the most obvious injury is done by the adults, larvae can severely damage and destroy the nitrogen root nodules of peas and vetch.

Seasonal history and habits.—In Europe, the biology of *S. lineatus* has been well studied and documented by several workers, including Andersen (1931) and Hans (1959). The seasonal history outlined below is drawn largely from Prescott and Reeher's (1961) studies in the Pacific Northwest, and Jackson's (1920) studies in Great Britain. Because of the relatively moderate climate of the coastal region of the Pacific Northwest, both the weevil and host plants develop 1–2 months earlier than in Great Britain and Europe.

Adults leave their overwintering sites and usually start flying about the middle of March in the Pacific Northwest, as temperatures approach 60°F, and move rapidly onto leguminous crops. By mid-March, adults have mated and begun laying eggs. Eggs are generally scattered singly on the soil surface near hosts but occasionally are laid on the plants. Females are capable of depositing large numbers of eggs over an extended period. Eggs begin hatching in mid- to late April and continue to hatch into late June. Newly hatched larvae move through the soil and

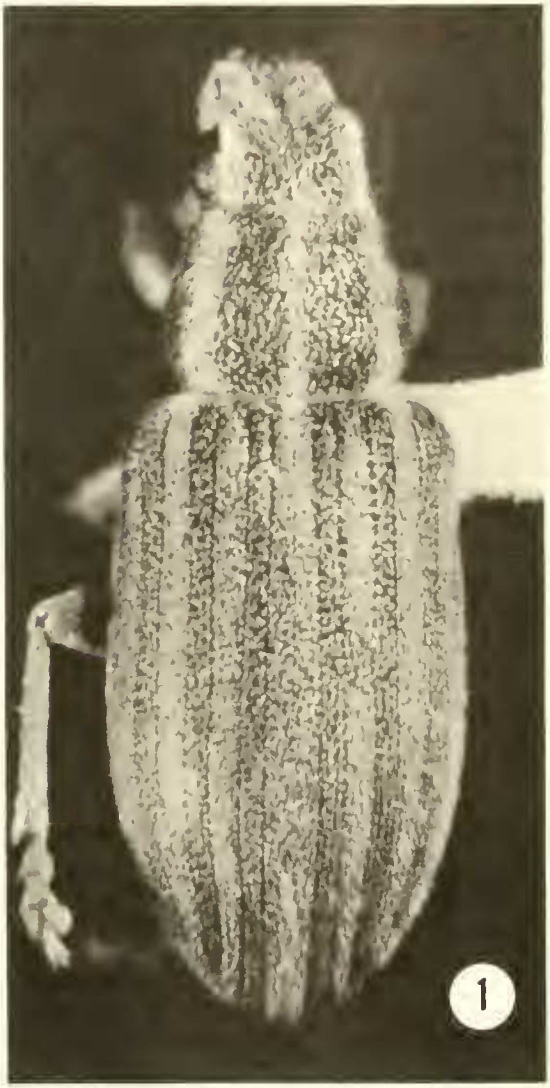

Fig. 1. *Sitona lineatus* (L.), the pea leaf weevil. Adult habitus, dorsal.

make contact with root nodules of the host plant. Young larvae feed on nodules by chewing a hole through one end and consuming the contents. In Europe, it has been noted that larvae also will feed on roots (Baranov, 1914). Mature larvae vacate the nodules and pupate in the soil. By early June, new adults begin to emerge from the soil, reaching peak levels from late June to mid-July. New adults fly intensively for several weeks, then disperse widely in search of alfalfa and red clover. From late summer through most of the fall, new adults enter a period of estivation, seeking refuge among roadside litter, grass clumps, and fence rows. In the Pacific Northwest, weevils become active again by mid-October and resume feeding on legumes.

In North America, there is one generation annually (Prescott and Reeher, 1961).

The newly emerged, sexually immature, adults do not begin to lay eggs until the following spring (Jackson, 1920). In Europe, the number of generations produced annually may vary. Molz and Schröder (1914) recorded 2 generations in Germany, and Rostrup (1915) lists the same in Denmark. In Sweden, Kemner (1917) mentioned only a single generation, as did Baranov (1914) for Russia.

The longevity of overwintered adults is approximately 2–3 months. Duration of the life stages in the Pacific Northwest, according to Prescott and Reeher, 1961, are as follows (numbers in parentheses refer to European populations): egg, 18 days (20–21); larva, 35 days (42–49); and pupa, 15 days (21).

Recognition features.—Adults of *S. lineatus* (Fig. 1) can be readily separated from other *Sitona* species occurring in eastern North America by the following combination of characters: Length 3.9–5.0 mm, form slender, elongate; body (devoid of scales) black, with antennae, tibiae and tarsi brownish red; dorsal scales brownish ochreous or greyish ochreous, interspersed with flat setae; pale scales tending to form median and sublateral stripes on the head and pronotum; scales of the elytra (Fig. 1) frequently arranged in alternate light and dark stripes; rostrum with a central furrow extending behind level of hind margin of eyes; and anterior margin of procoxae very narrowly or not at all separated from the transverse subapical furrow that traverses the ventral surface of the prothorax.

Larvae of *S. lineatus* have been described and illustrated in detail by Jackson (1920) and van Emden (1952). Prescott and Anderson (1961) gave characters and illustrations by which *S. lineatus* can be separated from the clover root curculio, *S. hispidulus*.

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The authors express their gratitude to D. R. Whitehead (Systematic Entomology Laboratory, IIBIII, USDA, Washington, D.C.) for confirming the identification of *S. lineatus*, and for sharing ideas about the possible means of introduction of this weevil. We are also grateful to R. D. Sale and J. F. Stimmel (Penn. Dept. of Agric., Harrisburg, PA) for the photograph of the adult habitus, and to R. J. Hill (PDA) for identifying the host plant, *Vicia villosa*.

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A NEW SPECIES OF *STENOTABANUS* (*BRACHYTABANUS*) (DIPTERA: TABANIDAE) WITH A KEY TO THE SPECIES OF THE SUBGENUS[1]

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Abstract.—*Stenotabanus* (*Brachytabanus*) **sphaeriscapus** Wilkerson, new species, from Bolivia is described and figured. A key is provided for comparison to the other two species of the subgenus, *S.* (*B.*) *longipennis* Kröber and *S.* (*B.*) *platyfrons* Fairchild.

The subgenus *Brachytabanus* was proposed by Fairchild (1942) to accommodate *Stenotabanus longipennis* Kröber. Subsequently, 2 other species, *S.* (*B.*) *platyfrons* Fairchild and *S.* (*B.*) *sphaeriscapus* Wilkerson new species, have been discovered. *Brachytabanus* may be defined as follows: female eyes bare, green with 3 purple bands; frons very broad, frontal index less than 2.0; basal callus protuberant, wider than high, not touching sides of frons; a shiny spot at vertex but no vestiges of ocelli; anterior tentorial pits dark and shiny; antennal annuli quite short, often only 3 annuli in evidence; and wing with a short appendix on R_{4+5} or none.

The above differs somewhat from Fairchild's (1942) definition of the subgenus because of characters on the species described here. The most diagnostic characters are the broad frons, round or oval protuberant basal callus, bare tentorial pits and reduced antennal annuli. See Fairchild (1969) for a discussion of and a key to the genus *Stenotabanus* and its subgenera.

KEY TO FEMALE *STENOTABANUS* (*BRACHYTABANUS*)

1. Basal callus about ¾ or more of basal width of frons. Frons narrower, frontal index 1.7–1.9. Antennal flagellum relatively short, 0.4–0.6 as long as basal plate (Costa Rica, Panamá, Colombia, Venezuela) ..... *longipennis*
– Basal callus about ½ or less of basal width of frons. Frons broad, frontal index 1.5 or less. Antennal flagellum longer, about ¾ as long as basal plate 2
2. Antennal scape inflated, nearly spherical, shiny yellowish brown. Basal plate about as wide as long (Bolivia) .... *sphaeriscapus* n. sp.
– Antennal scape normal, not spherical, partially shiny yellowish brown. Basal plate distinctly longer than wide (1.3–1.4 times longer than wide) (N Argentina) .... *platyfrons*

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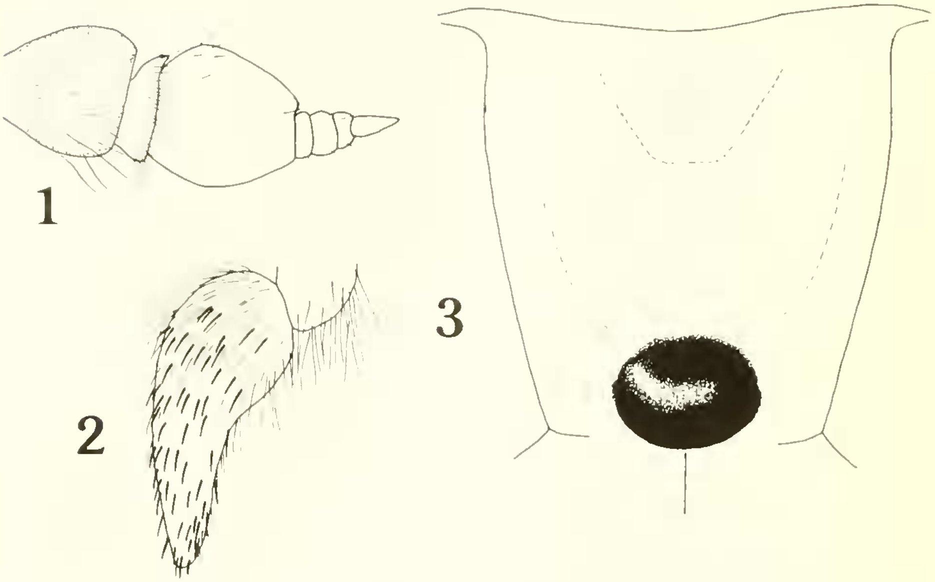

Figs. 1–3. Female, *Stenotabanus* (*Brachytabanus*) *sphaeriscapus*. 1, Antenna. 2, Palpus. 3, Frons.

Stenotabanus* (*Brachytabanus*) *sphaeriscapus **Wilkerson New Species**

Figs. 1–3

A small pale yellowish species with a very broad frons and protuberant black basal callus. Antennal scape shiny and spherical; basal plate and annuli short and compact; basal plate as long as wide. Abdomen above nearly black, with a broad middorsal pale stripe.

Female holotype.—Length: body 8.5 mm; wing 8 mm. Head structures in figures 1–3. Frontal index 1.5. Frons convergent below, width at vertex/width at base = 1.5. Frons pale yellow pollinose with sparse short black hairs and sparse yellow recumbent, scale-like hairs. Area near vertex slightly raised with a central shiny yellow patch. Remnants of ocelli not evident. Basal callus black, protuberant. Central area of frons slightly concave. Eye color and pattern not noted. Subcallus, gena and frontoclypeus pale yellow pollinose. Genal hairs and hairs of beard short and pale yellow except for a few black hairs on upper gena. Frontoclypeus sparsely short pale yellow haired. Anterior tentorial pits shiny black. Antennal scape nearly spherical, shiny yellowish brown, pedicel and flagellum pale yellow and pale yellow pollinose. Antennal hairs pale yellow. Palpus yellow, pale yellow and black haired as in Fig. 2. Proboscis pale yellowish brown, without shiny sclerotized areas; short, less than head height; labella relatively large, a little longer than palpal length.

Scutum and scutellum yellowish brown pollinose, pilosity a mixture of black hairs and yellow scale-like hairs. Scutum very faintly striped with a faint bluish cast anteriorly. Pleuron pale yellowish gray pollinose and sparsely pale yellow haired. Legs mostly yellowish brown and pale yellow haired. Foretibia darkened apically and mostly black haired. Mid- and hindtibiae with a few apical black hairs. Wing, including costal cell, glass-clear; venation normal, vein R_{4+5} (fork of 3rd vein) with a short appendix. Basicosta bare. Halter pale yellowish brown.

Abdomen above with a middorsal, nearly parallel sided pale yellowish brown and pale yellow haired stripe; on either side of this stripe, and about equal in width to it, are dark brown and black haired stripes; lateral areas and posterior borders of tergites 4–6 pale yellowish brown, and pale yellow haired. Abdomen ventrally pale yellow and pale yellow haired except for sternite 1 and anterior portion of 2 which have black integument showing through sparse pale yellow pollinosity.

Holotype.—♀, Bolivia, Cochabamba Dept., Villa Tunari, 240 m elev, 5-IX-1983, R. Wilkerson. To be deposited in the Florida State Collection of Arthropods (FSCA), Gainesville, Florida.

Discussion.—*Stenotabanus* (*B.*) *sphaeriscapus* n. sp. is quite similar to *S.* (*B.*) *platyfrons* but differs by having a shiny, nearly spherical antennal scape (thus the name), and by having a basal plate as wide as long (1.3 and 1.4 times longer than wide in *S.* (*B.*) *platyfrons*). In addition, the frons of *S.* (*B.*) *sphaeriscapus* is more convergent below (width at vertex/width at base 1.5 vs 1.3 and 1.2) than that of *platyfrons*, and the basal callus occupies a larger proportion of the basal width of the frons (0.50 vs 0.40 and 0.46). I believe the antennal characters are quite distinctive but the frontal characters may prove to be variable as more specimens become available.

***Stenotabanus* (*Brachytabanus*) *longipennis* Kröber**

Stenotabanus longipennis Kröber 1929: 125, holotype, ♀, Vienna.
Stenotabanus (*Brachytabanus*) *longipennis*: Fairchild 1942: 300–301. Fairchild 1964: 175, ♂. Wilkerson 1979: 219–220.

Fairchild (1942) proposed the subgenus *Brachytabanus* for *S. longipennis* Kröber. I have seen Panamá material as follows: Panamá Prov, 1 ♂, Las Cumbres, 9-VI-1958 (G. B. Fairchild coll) (in coll G.B.F.); 1 ♀, Las Cumbres, 22-VI-1966 (G. B. Fairchild) (R.C.W.). Darién Prov, 1 ♀, Río Paya, 2-VI-1969 (G. B. Fairchild) (G.B.F.); 1 ♀, Río Imamado, Río Jaque, 17-IV-1947 (A. Wetmore) (G.B.F.); 1 ♀, Río Tacarcuna, 1900 ft (575 m), 9-VII-1963, compared with type of *S. longipennis* by G. B. Fairchild, Vienna, 1964, with good agreement (G. B. Fairchild) (G.B.F.). I also have before me the following specimens collected in Colombia by M. A. Tidwell (all in FSCA): 18 ♀, Antioquia Dept, Río Arquia, Pto Palacio, 9-IX-1977 (17) and 14-II-1978 (1) biting man; 1 ♀, Valle Dept, Bajo Calima, 6-II-1979. In addition there are records from the literature as follow: Fairchild (1942), 1 ♀, Venezuela, XI-1936; 14 ♀, Colombia, Muzo and Villavicencio; 1 ♀, Panamá, Gamboa, C.Z., 9-VII-1924; 2 ♀, Panamá, Utevey, near Pacora, 6-VIII-1941, on horse. Bequaert and Renjifo (1946), Colombia, Santander Dept, Bocas del Rosario, Río Magdalena; Colombia, "Upper Magdalena River." Lee et al. (1969), 1 ♀, Valle Dept, Río Raposo, 17-IX-1964. Hogue and Fairchild (1974), 1 ♂, Costa Rica, Puntarenas, Palmar.

See the key and discussion of *S.* (*B.*) *sphaeriscapus* for distinguishing characters. It is interesting to note that the presumed male of this species does not have shiny anterior tentorial pits but does have a pair of dark brown spots on the subcallus, these lacking in the female. Fairchild notes on 2 of the above female specimens that the eye pattern is glaucus green with 3 narrow reddish purple bands.

***Stenotabanus* (*Brachytabanus*) *platyfrons* Fairchild**

Stenotabanus (*Brachytabanus*) *platyfrons* Fairchild 1964: 174, holotype, ♀, Argentina, Tucumán, CAS (examined); Coscarón 1975: 26–28, pl. 5, A–H.

In addition to the holotype I have before me a paratype from Argentina, Río Bermejo, XI-916. The holotype bears the date 16–19-I-1957. Another paratype is in the Museum of Comparative Zoology, from Argentina, Jujuy. Fairchild's (1964) figure proves to be of the paratype from Río Bermejo, not of the holotype. The basal callus of the holotype is without the upward extension shown in his figure. Coscarón (1975) redescribes this species and gives complete figures including female genitalia. Also, he saw 2 females from Argentina, Tucumán Prov, Río Viejo, 8-X-1943. *Stenotabanus platyfrons* has an eye pattern of 3 narrow dark lines on a light green background.

This species is quite close to *S.* (*B.*) *sphaeriscapus* n. sp. See the key and discussion section of *S.* (*B.*) *sphaeriscapus* for distinguishing features.

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DESCRIPTION AND LIFE HISTORY OF A NEW SPECIES OF *NEMATUS* (HYMENOPTERA: TENTHREDINIDAE) ON *ROBINIA HISPIDA* (FABACEAE) IN NEW YORK

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Abstract.—*Nematus* **hispidae** Smith, n. sp., is described from a large series of adults reared from *Robinia hispida* in Ithaca, N.Y. Aspects of biology and life history are discussed and compared with that of *N. tibialis.* Notes on parasitism by *Cleptes semiauratus* (Hymenoptera: Chrysididae: Cleptinae) and the current distribution of this parasitoid in North America are presented.

The rose acacia, *Robinia hispida* L. (Fabaceae), is a widely planted ornamental shrub, native to southeastern U.S.A. In 1980 a large population of sawfly larvae was observed defoliating a stand of rose acacia on the Cornell University campus at Ithaca, N.Y. Discussions with Cornell's cooperative extension associates provided no insight into the identity of the sawfly. Apparently, sawflies attacking the rose acacia had attracted little attention in the past. A large series of larvae were collected and reared to adults. Specimens were sent to DRS for identification. When it became apparent that the species was either new to science or new to the U.S., more detailed biological studies were initiated by DCD. It was eventually determined that there are two species of *Nematus* feeding on *R. hispida,* one of which was undescribed. In this paper *Nematus hispidae* n. sp. is described and its life history is summarized and compared with *N. tibialis* Newman, the other species feeding on the rose acacia.

The sections on the taxonomy are by the junior author, those on the life history and parasitism are by the senior author.

Nematus hispidae Smith, New Species

Figs. 1–5, 9, 10

Female.—Length, 5.5–7.0 mm. Dark yellow with following black: Antenna (except anterior surface of scape), ocellar and postocellar areas with black expanded anteriorly in short armlike extensions one directed toward each antenna, large triangular spot on mesoprescutum, longitudinal broad stripe on each lateral lobe of mesonotum, posterior half or less of mesoscutellum with mesal stripe extending forward, mesopostergite, sometimes upper half of mesepimeron and extreme upper corner of mesepisternum, metascutellum and area surrounding cenchri, mesal portion of terga 1–8 appearing as a broad longitudinal dorsal stripe, hindtarsus, and sheath (except base); hindtibia darkened, increasingly dark to almost black toward apex; apex of mandible reddish brown; wings hyaline, veins brown, stigma amber.

Shining, covered with fine white pubescence. Antennal length about 2½ head width, in ratio of 6.0:2.3; 1st and 2nd segments each broader than long, segments 3–5 subequal in length, segments 6–9 slightly decreasing in length. Clypeus circularly emarginated for nearly ½ its medial length; malar space subequal to diameter of front ocellus; distances between eye and hindocellus, between hindocelli, and between hindocellus and posterior margin of head subequal. Hindbasitarsus shorter than length of following segments combined, as 2.0:2.7. Tarsal claw with long inner tooth. Sheath slender and tapering to pointed apex in dorsal view, in lateral view straight above, rounded below (Figs. 1, 2). Lancet with about 19 serrulae, each serrula flattened, separated by shallow circular notch, and with about 10 subbasal teeth on ventral margin; short intersegmental hairs present (Fig. 3).

Male.—Length, 5.0–6.0 mm. Coloration similar to that of female but black areas slightly more extensive: black in front of ocelli not always produced into armlike extensions, anterior margin of black straight or rounded, extending about halfway to antennae; mesonotum mostly black, at most with pale areas on sutures separating prescutum and lateral lobes; spots on meson of terga slightly broader. Structural characters as for female. Genitalia in Figs. 4, 5.

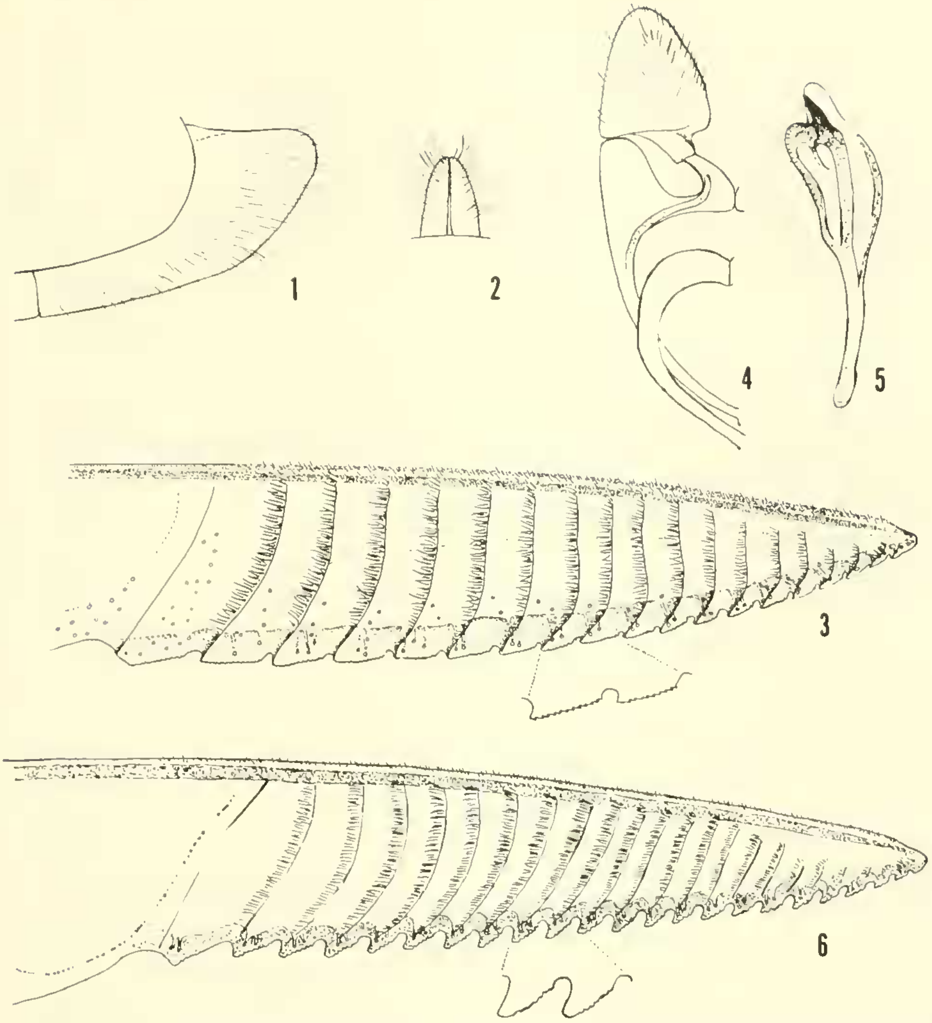
Holotype.—♀, New York, Tompkins Co., Ithaca, reared 80-05, D. C. Darling; defoliating *Robinia hispida*, Cornell campus, lab reared. Collected as late-instar larvae 10 June 1980, adult first emerged 30 June 1980. Deposited in Cornell University Insect Collection.

Paratypes.—14 ♀, 8 ♂, same data as for holotype. Deposited at Cornell, the National Museum of Natural History, Washington, D.C., the Canadian National Insect Collection, Ottawa, and Oregon State University Insect Collection, Corvallis.

Host.—*Robinia hispida.*

Larva.—Typical of the Nematinae and *Nematus*, with prolegs on abdominal segments 2–7 and 10, antenna conical, and 10th tergum with a pair of caudal protuberances. Early feeding stages dark blackish (Fig. 9). Late feeding stages green when alive, with head and 10th tergum amber and with black tubercles on body. Abdominal segments 1–8 apparently 5-annulate with black tubercles as follows (Fig. 10): 1st annulet with one small spot laterally; 2nd annulet with 2 large spots above spiracle; 3rd annulet with 2 small spots posterior to spiracle; 4th annulet usually with 4 spots, the upper 2 the largest; 5th annulet without spots; large spot on subspiracular lobe; 3 nearly confluent spots on surpedal lobe. Prepupa without spots, entirely green.

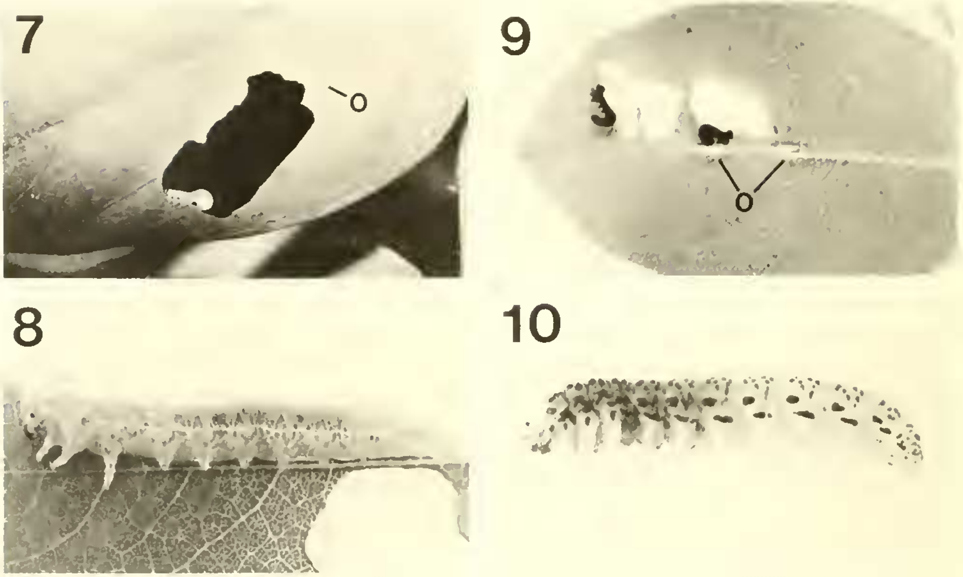
Remarks.—*Nematus hispidae* belongs in the *oligospilus* group of *Nematus* because of its long slender sheath and long lancet with intersegmental hairs; other groups may have the sheath apex expanded or have a very short sheath which is not longer than high and the lancet may be bare, with intersegmental spines, or be very short and triangular. Among species in the *oligospilus* group, structural characters and coloration place *hispidae* close to *tibialis* Newman, but it is separated from *tibialis* by the black or partly black meso- and metascutella (dark



Figs. 1–6. 1–5, *Nematus hispidae*. 1, Sheath, lateral view. 2, Sheath, dorsal view. 3, Lancet. 4, Harpe and parapenis, ventral view, left half. 5, Penis valve. 6, *Nematus tibialis*, lancet.

yellow in *tibialis*), the paler hindtibia (black in *tibialis*), and the flat serrulae of the lancet (deep and pointed with distinct anterior and posterior margins in *tibialis* (Fig. 6)). The male of *tibialis* is not known. The following characters will help distinguish *hispidae* from other members of the *oligospilus* group: short malar space (some species, like *oligospilus* Foerster, have a broad malar space, more than twice the diameter of an ocellus); flat serrulae (deeper and pointed in most other species); and mostly black dorsum (other species are not as extensively black or are all yellowish to orange). The male can be separated only by comparing the genitalia with the illustrations, Figs. 4–5. The larvae of *hispidae* differ from *tibialis* also, as will be discussed subsequently.

This new species was first expected to be *tibialis*, but after close examination it was evident that two species are involved. Since specimens could be masquer-



Figs. 7–10. 7, 8, *Nematus tibialis*. 7, Oviposition scar and first-instar larva. 8, Final instar larva. 9, 10, *Nematus hispidae*. 9, Oviposition scars and first-instar larvae. 10, Final instar larva. O = oviposition scar.

ading under *tibialis* in collections, all available collections of that species were checked, but no additional specimens of *hispidae* were found. It is possible that the species was adventive from the Old World, but I have checked many Palearctic species as well as keys to species of that region and have found nothing that resembles *hispidae*.

Larvae associated with *Robinia* in the USNM collection were checked, and I found a number that resemble the larvae of *hispidae* though none are with associated adults. These larvae are from the following: Pa., Perry Co., Toboyne Township, May 29, 1980, defol. black locust; Md., Caroline Co., Denton, May 23, 1973, on locust; S.C., Clemson, April 20, 1955, black locust; N.C., Mt. Mitchell, August 26, 1950, *Robinia hispida*; Mass., Eastham, June 12, 1957, *Robinia pseudoacacia*; Okla., Stillwater, May 4, 1965, on black locust. Though adults of *hispidae* are known only from the type-locality, these records of larvae indicate a wide distribution and the possibility that other species of *Robinia* may be hosts.

A Comparison of the Life History of *Nematus hispidae* and *N. tibialis*

Surveys were initiated in early May of 1981, 1982 and 1983, before the buds of *Robinia hispida* were opened. Eggs and first-instar larvae were first observed around the middle of May. Eggs could be found in two sites on the compound leaves of the plant and the associated first-instar larvae differed dramatically in color. The most abundant oviposition sites were blister-like swellings on the surface of the leaf (Fig. 7). All newly emerged larvae feeding in the vicinity of these oviposition sites were pale greenish-white with a brown head capsule (Fig. 7). Oviposition also occurred in the midribs (Fig. 9). First-instar larvae associated with this oviposition site were uniformly black (Fig. 9). In one instance, the emergence of an entirely black larva from a swelling in the midrib was observed in the laboratory. There were also two distinct types of later-instar larvae on *R. hispida*—uniform green (Fig. 8) and green with very prominent and contrasting black tubercles (Fig. 10). The blister-like oviposition scar, light green first-instar larva and final instar larva also of uniform color agree exactly with the descriptions provided by Comstock (1880) for *tibialis* (cited as *N. similaris* Norton) feeding on *Robinia pseudoacacia* (black locust) in Washington, D.C. The identity of these sawflies as *tibialis* is further supported by the results of oviposition observed under laboratory conditions in 1983. Field collected females were isolated with twigs of *R. hispida* that were determined to be free of eggs. Only blister-like oviposition scars were subsequently located and only uniformly green first-instar larvae emerged. Examination of the lancets of the females isolated with the twigs confirmed their identity as *tibialis*.

There also appear to be differences in the phenology of the two species of *Nematus* in Ithaca. *Nematus hispidae* directly developed to the adult stage and does not have an obligate diapause. Larvae were collected June 9 and 10, 1980 and pupation occurred between June 11 and 15. Adults emerged during the last week of June and first week of July. In 1981 and 1982 only *tibialis* was abundant in the study area. Individual larvae were reared to pupation. None emerged that summer, and the cocoons were overwintered at 5°C. Unfortunately, development did not resume the following spring. Consistent with these negative results and the seasonal abundance of the sawfly population, is the suggestion that *tibialis* is univoltine with an obligate diapause, probably mediated by photoperiod. This would explain my inability to break the diapause; photoperiod was not carefully regulated. Comstock (1880) states there are two and possibly 3 broods of *tibialis* in Washington, D.C.

Reproduction is also different in these two species. *Nematus tibialis* is parthenogenetic (thelytokous), whereas *hispidae* is bisexual, males and females occurring in approximately equal numbers.

PARASITISM OF *NEMATUS HISPIDAE*

In the early summer of 1981, the year following the defoliation of *R. hispida*, *Cleptes semiauratus* (L.) [Hymenoptera: Chrysididae: Cleptinae] was abundant in the study site. A one hour sampling period on June 11 produced approximately 25 specimens, and many more of the fast-flying wasps evaded capture. The wasps were observed on the leaves, areas frequented by the *Nematus* larvae.

Kimsey (1981) reviewed the Cleptinae of the New World and noted that *C. semiauratus* is "undoubtedly adventive" in eastern North America with the only previous records from New Jersey. This suggests the possibility that we were dealing with a recently introduced sawfly. Two factors suggest that *hispidae* is *not* recently introduced from the Palearctic. Firstly, both the sawfly (see "Remarks" section) and the parasitoid are known from many collecting localities in eastern North America. There is an additional specimen of *C. semiauratus* in the Cornell Collection [NY: Ludlowville, L. L. Pechuman, 30 June 1981] about 7 miles from type locality of *N. hispidae*, and also a specimen from Canada [Ontario: Hamilton, VI 19 1979, K. L. Bailey] in the University of Guelph collection. Secondly, the genus *Robinia*, the food plant of the sawfly, is restricted to the New World (Willis, 1973). It seems more likely that *hispidae* is an uncommon species endemic to the southern U.S., the range of its host plant, *R. hispida.* The planting of the ornamental rose acacia in northeastern U.S. provided an opportunity for *C. semiauratus* to parasitize *hispidae.*

I was also able to demonstrate parasitism in the laboratory. *Cleptes semiauratus* adults were brought back to the lab and a female was placed in a petri dish with a *Nematus* cocoon. The identity of the cocoon, *tibialis* or *hispidae,* was uncertain. The female immediately began to examine the cocoon and was left with the cocoon overnight. Cleptines chew a hole in the host cocoon and deposit an egg with the tubular ovipositor characteristic of Chrysididae. They then seal up the hole with masticated leaf litter (Clausen, 1940). This plug was observed the next day. The sawfly cocoon was dissected in mid-winter and the characteristic cleptine larvae was found in the cocoon. This specimen is deposited in the Cornell University Insect Collection, Lot #1123. Unfortunately, this experiment could not be replicated due to the small numbers of sawflies collected in 1981 and 1982.

Cleptes semiauratus was not observed in the study area in 1980, the year of peak abundance of *hispidae.* The marked increase in the numbers of the parasitoid was correlated with a drastic decline in the population of *hispidae.* Parasitism by *Cleptes semiauratus* may have been responsible for the dramatic decrease in the populations of *Nematus* on *Robinia hispida* in Ithaca, N.Y. This suggestion is supported by the documented ability of *C. semiauratus* to attack *Nematus* in North America and the host range of nematine tenthredinids attacked in Europe, *Nematus* spp., *Pachynematus* spp. and *Pristiphora abietina* (Christ) (see Gauss, 1964).

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NEW SPECIES OF PHYCITINAE (LEPIDOPTERA, PYRALIDAE) FROM TEXAS, WITH DESCRIPTION OF A NEW GENUS

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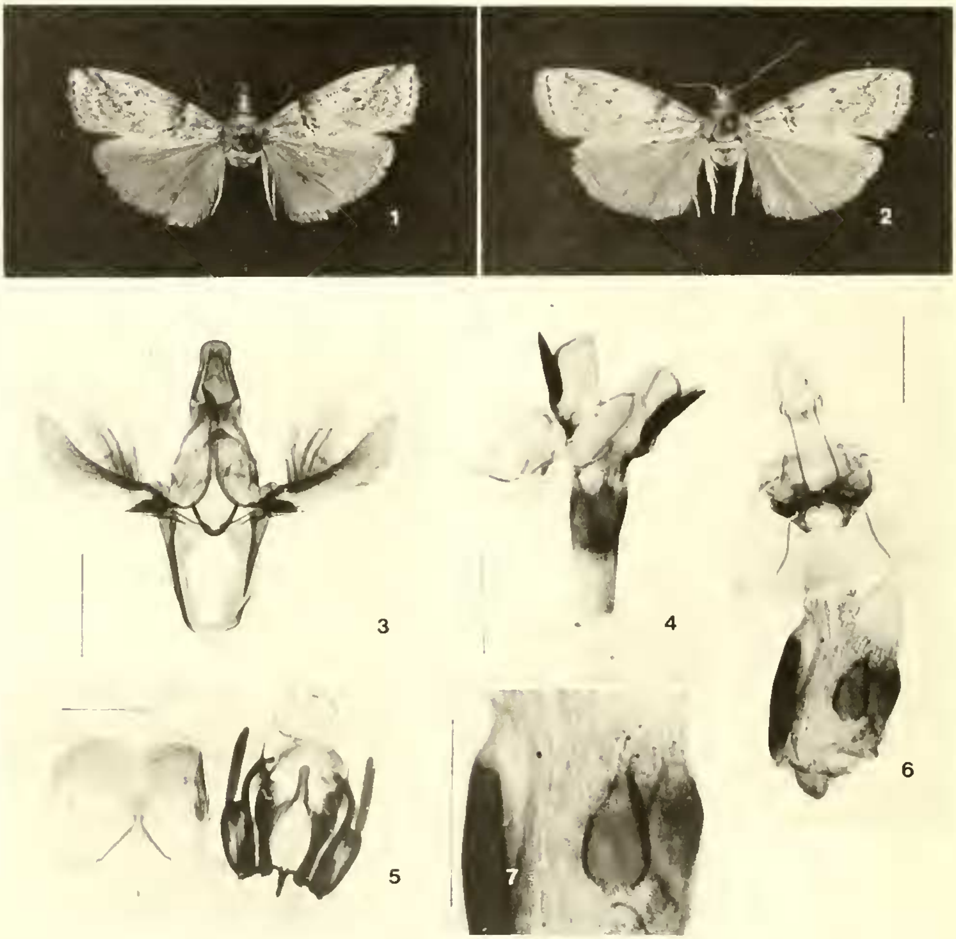
Abstract.—*Meroptera anaimella, Melitara apicigrammella,* and *Homoeosoma parvalbum* are described. A new genus, *Pseudocabotia,* is described, with *P. balconiensis* described as sole included species. Imagines, wing venation, and male and female genitalia are figured.

The following four new phycitine pyralids have resided for many years in the senior author's collection, but have recently been augmented by additional specimens collected by the junior author. All are known only from examples collected in Texas; the *Meroptera, Melitara,* and *Homoeosoma* from the Big Bend region; the *Pseudocabotia* from the Edwards plateau.

Meroptera anaimella **Blanchard & Knudson, New Species**
Figs. 1–7

Description.—*Head:* Front and vertex light orange brown. Maxillary palpi light orange brown aigrettes. Labial palpi upcurved, not quite reaching vertex, light orange brown. Antennae simple, pale ochreous dorsally, naked and minutely setose ventrally, male with sinus at base of shaft, containing 5 or 6 short, black, thorn-like processes, scale tuft pale ochreous. Chaetosema present. Collar light orange brown. *Thorax:* Patagia and mesonotum pale ochreous with black scaling anteriorly. *Abdomen:* Pale ochreous lightly sprinkled with black scales. *Forewing:* Ground color whitish ochreous lightly peppered with black scales over median area, mainly near costal margin. Antemedial band outwardly oblique from costa at ¼ the distance from base to dorsal margin at ⅓ the distance from base, consisting of a black outer line, broad at costa, diminishing beyond and not quite reaching dorsal margin, and a black inner line from dorsal margin to cell, separated by ground color. The basal space is suffused with light orange, appearing slightly paler than the remainder of the wing. Discal dots widely separated, black. Subterminal band faint, best defined near costal margin, with an inwardly directed cusp above cell and another over lower fold, weakly dentate between cusps. Outer and inner lines blackish, separated by ground color. Terminal dots confluent. Fringe pale ochreous. *Hindwing:* Pale ochreous, suffused with fuscous along outer margin, fringe whitish ochreous. *Length of Forewing:* Males: N = 8, 10.4–11.8 mm, average 11.0 mm. Females: N = 12, 10.1–12.0 mm, average 11.4 mm. *Male genitalia* (Figs. 3–5): Valva with short triangular clasper, about ¼ the length of the valva. Clasper with short spines on posterior surface and a single, larger



Figs. 1–7. *Meroptera anaimella*. Fig. 1, Holotype ♂. Fig. 2, Paratype ♀. Fig. 3, ♂ genitalia, on slide AB 5362 (by ECK), Presidio Co., Texas. Fig. 4, Aedeagus with inflated vesica, same specimen and slide as Fig. 3. Fig. 5, Sclerotization and tufts of 8th abdominal segment, same specimen and slide as Fig. 3. Fig. 6, ♀ genitalia, on slide ECK 845, K-Bar Research Station, Brewster Co., Texas. Fig. 7, Magnification of corpus bursae, showing signa, same specimen and slide as Fig. 6. Segments = 1 mm.

terminal spine. Aedeagus with two equal sized cornuti. *Female genitalia* (Figs. 6, 7): Sterigma with broad well sclerotized plate, bearing well sclerotized lateral arms projecting into ductus bursae. Corpus bursae with longitudinal ridges of scobinations and two opposed heavily scobinate patches.

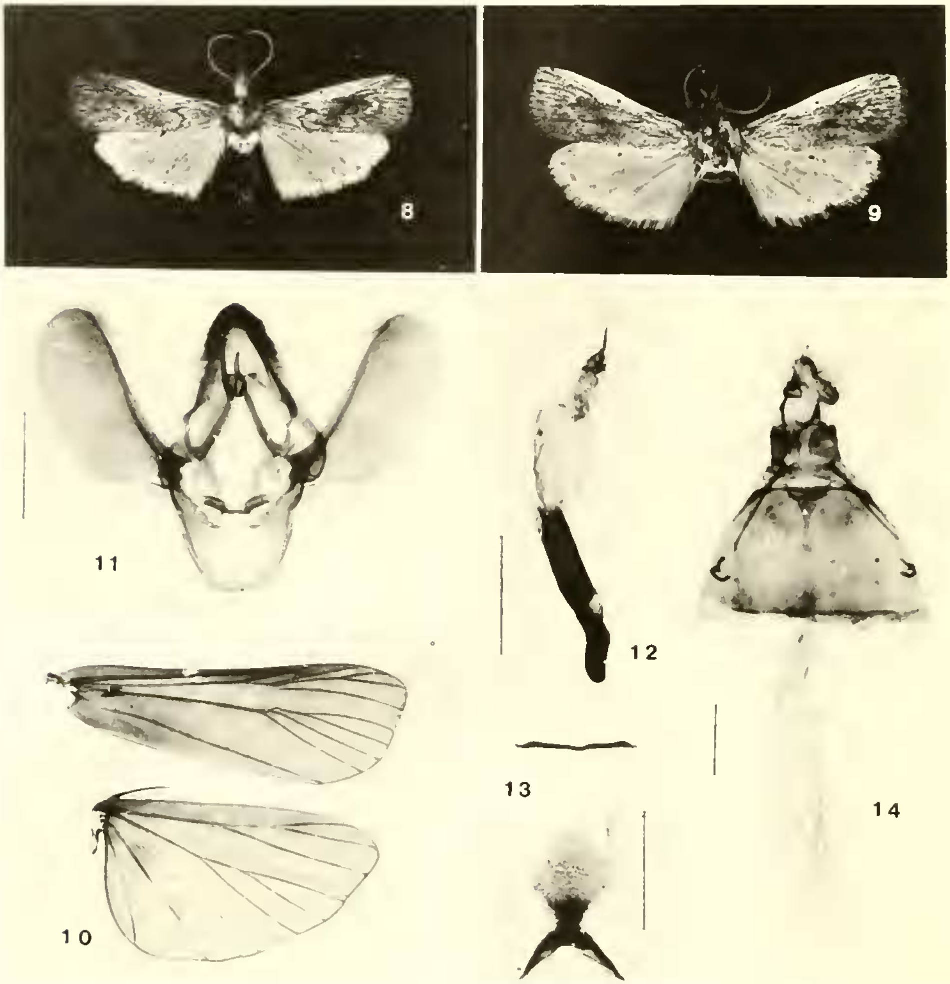
Holotype (Fig. 1).—♂, Shafter, Presidio Co., Texas, 9-VII-69, genitalia on slide AB 1750, A. & M. E. Blanchard collectors, deposited in the National Museum of Natural History. Paratypes.—Same locality as holotype, 9-IX-69, 1 ♂, 1 ♀; Presidio Co., Texas, Ruidosa Hot Spring, 8-VII-69, 1 ♂, collected by A. & M. E. Blanchard. Brewster Co., Texas, Big Bend Nat'l. Park, Dugout Wells, 13-IX-82, 1 ♀; K-Bar Research Station, 9-VIII-83, 1 ♀; Rio Grande Village, 6-IV-84, 5 ♂, 10 ♀, all collected by E. C. Knudson.

Remarks.—This new species is superficially indistinguishable from *Meroptera* *mirandella* Ragonot, and quite similar to *M. cviatella* Dyar. From both species, it differs in the shape of the clasper in the male, the larger, differently shaped, sclerotized plates on the corpus bursae, and the more strongly developed lateral arms of the sterigma in the female. The male genitalia are most similar to *M. abditiva* Heinrich, but *abditiva* has unequal sized cornuti in the vesica and it also differs in color and maculation. No other species of *Meroptera* is known from the Big Bend region of Texas, but *cviatella* occurs in the Texas panhandle. The host and early stages are unknown, but moths were collected in areas where both cottonwood and willow occur.

Melitara apicigrammella **Blanchard & Knudson, NEW SPECIES**
Figs. 8–14

Description.—*Head:* Front gray, each scale narrowly white tipped. Vertex grayish white, darker gray posteriorly. Maxillary palpi squamous, gray dorsally, white ventrally, length equal to eye diameter. Labial palpi porrect, dark gray, exceeding front by 2½ eye diameters. Antennae bipectinate in male, shortly bipectinate in female, flagellum whitish, variably sprinkled with black scales. Collar gray. *Thorax:* Tegulae and patagia gray, mixed with a few white scales, each scale white tipped, mesonotum mainly whitish centrally, dark gray posteriorly. Ventral surface mainly whitish. *Abdomen:* Whitish, with a few black scales dorsally. First abdominal segment with white, paired lateral scale tufts. *Forewing:* Ground color light gray, heavily suffused with fuscous below costal margin over median area. Costal margin mainly grayish white, with scattered black scales. Antemedial line black, margined inwardly with white, sharply produced into two outwardly directed points above, and over cell and again produced to a longer outwardly directed point over median vein. Below median vein, the antemedial line forms a broad, inwardly directed point over lower fold. Single elongate discal spot obscured by fuscous suffusion. Subterminal band indistinct, angled inwardly from costal margin and moderately dentate, consisting of a pale gray central line flanked by dark gray inner and outer lines. Veins lightly black scaled over outer ⅓ of wing. Terminal intervenular dashes black, conspicuous. Fringe gray. Undersurface grayish, terminal dashes weakly indicated. *Hindwing:* White, lightly suffused with fuscous at apex in male; more heavily suffused in female. Terminal line narrow, fuscous. Fringe whitish. *Venation* (Fig. 10): Hindwing: Sc and Rs stalked for ⅓ their lengths, beyond cell; M3 and Cu1 stalked. *Length of Forewing:* Males: N = 11, 11.3–14.6 mm, average 13 mm. Females: N = 11, 13.3–17.7 mm, average 15.6 mm. *Male genitalia* (Figs. 11–13): Bifid apical processes of gnathos slender and pointed. Anellus with base well sclerotized, lateral arms weakly sclerotized. Aedeagus moderately long (length 7× width), vesica unarmed. *Female genitalia* (Fig. 14): Ostium funnel shaped, membranous. Ductus bursae and corpus bursae membranous, without signum. Holotype.—(Fig. 8). ♂, Terrel Co., Texas, Sanderson, 28-IX-80, collected by E. Knudson and deposited in the National Museum of Natural History. Paratypes.—Same data as holotype, 7 ♂; Brewster Co., Texas, Big Bend Nat'l. Park, K-Bar Research Station, 9-VIII-83, 1 ♀; Big Bend Nat'l. Park, Rio Grande Village, 6-IV-84, 2 ♂, 9 ♀, all collected by E. Knudson. Big Bend Nat'l. Park, Chihuahuan desert near Nugent Mt., 1-V-72, 2 ♂; Big Bend Nat'l. Park, Dugout Wells, 1 ♀, collected by A. & M. E. Blanchard.

Remarks.—This new *Melitara* is easily distinguished from the other species in



Figs. 8–14. *Melitara apicigrammella*. Fig. 8, Holotype ♂. Fig. 9, Paratype ♀, K Bar Research Station Brewster Co., Texas. Fig. 10, Wing venation of ♂ paratype, on slide ECK 830 (by AB), same data as holotype. Fig 11, ♂ genitalia of paratype, on slide ECK 827, same data as holotype. Fig. 12, Aedeagus and inflated vesica of paratype, on slide ECK 838, same data as holotype. Fig. 13, Sclerotization of 8th abdominal segment of ♂ paratype, on slide AB 5359, near Nugent Mt., Brewster Co., Texas. Fig. 14, ♀ genitalia of paratype, on slide ECK 849, Rio Grande Village, Big Bend Nat'l. Park, Texas. Segments = 1 mm.

the genus by features of the maculation, particularly the well defined black terminal dashes and obscure subterminal band and discal spot, which are well defined in the other species. In superficial appearance, it is more apt to be confused with *Olycella subumbrella* (Dyar), but differs in the labial palpi, which are of the *Melitara* type. The male genitalia differ from the other species of *Melitara*, chiefly in the shape of the gnathos and the longer, more slender aedeagus. It also differs in the sclerotization of the 8th abdominal segment. The female genitalia are not significantly different from *Melitara dentata* (Grote). The forewing venation differs slightly in that Rs and Sc are stalked beyond cell rather than approximate.

Pseudocabotia Blanchard & Knudson, New Genus

Type-species.—*Pseudocabotia balconiensis* Blanchard & Knudson.

Description.—*Head:* Front conical. Maxillary palpi squamous, ascending to ½ eye diameter. Labial palpi alike in both sexes, porrect, slightly downcurved, exceeding front by 1½ eye diameters. Tongue well developed. Antennae simple, minutely setose ventrally, base of flagellum unmodified. Chaetosema present. *Forewing* (Fig. 17): Smooth, 11 veins; R_2 from cell, shortly before upper outer angle; R_3 and R_4 united and anastamosed with R_5 at half its distance beyond cell; otherwise as in *Cabotia* Ragonot. *Hindwing* (Fig. 17): As in *Cabotia. Male genitalia* (Figs. 18–20): Uncus subtriangular, lightly setose. Gnathos undivided, elongate, apex pointed. Transtilla incomplete. Valves simple, narrow, costa lightly sclerotized, clasper absent. Anellus V shaped, well sclerotized. Aedeagus sinuate, vesica lightly scobinate. Eighth abdominal sternite represented in Fig. 20. Scale tufts, if originally present, not preserved in dissection. *Female genitalia* (Fig. 21): Apophyses anteriores equal in length to apophyses posteriores. Ostium bursae narrowly funnel shaped, membranous. Ductus bursae membranous, half the length of corpus bursae. Corpus bursae with diverticulum posteriorly, bearing ductus seminalis. Signa well developed, consisting of vertical rows of thornlike spines and a patch of similar spines at junction of diverticulum and corpus bursa.

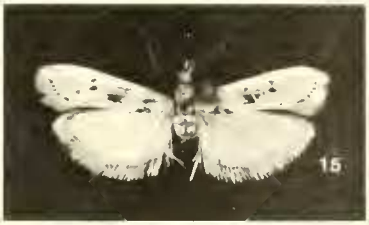
Remarks.—Based on venational characteristics, this new genus falls into Heinrich's group 2, division A of New World Phycitinae, but cannot be further assigned (Heinrich, 1956). The female genitalia are distinctive but similar to *Cabotia* Ragonot. The male genitalia differ from those of *Cabotia* in the shape of the gnathos and the absence of a clasper, in this being quite close to *Harnocha* Dyar, which differs in forewing venation. *Cabotia* has different maxillary palpi, which are aigrettes, resting in grooves in the labial palpi. The female of *Harnocha velassa* Dyar is still unknown.

Pseudocabotia balconiensis Blanchard & Knudson, New Species

Figs. 15–21

Description.—*Head:* Front and vertex pale ochreous. Maxillary palpi whitish, labial palpi brown laterally, whitish medially. Antennae brown scaled dorsally. *Thorax:* Patagia and mesonotum ochreous. Whitish beneath. *Forewing:* pale ochreous, costa broadly margined with white. Antemedial line indicated by a black dorsal spot ⅙ the distance from base and obscure black scaling above, extending to, but not beyond cell. Near middle of wing is a prominent black spot below cell. Discal spot double, the lower spot more prominent. Subterminal line obscure, whitish, margined by inner row of faint black spots, oblique from near apex to dorsal margin at outer ¼. Terminal spots black, well defined, not reaching apex. Fringe pale ochreous. *Hindwing:* Shining pale ochreous, with narrow fuscous terminal line. Fringe pale ochreous. *Length of forewing:* Males: N = 2, 7.1 and 8.3 mm., Females: N = 1, 6.4 mm. *Male and female genitalia:* As described for genus.

Holotype.—♀, Kerr Co., Texas, 10 miles west of Hunt, 4-IX-81, with genitalia slide ECK 215, collected by E. Knudson and deposited in the National Museum of Natural History. Paratypes.—Same locality as holotype, 25-VIII-81, 1 ♂, collected by E. Knudson. Comal Co., Texas, Guadalupe River near New Braunfels,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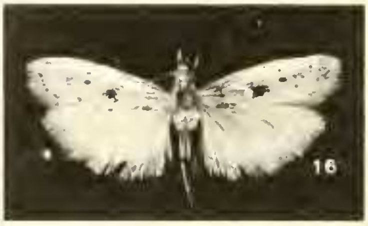
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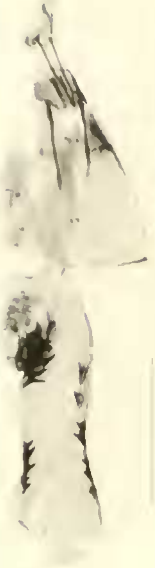
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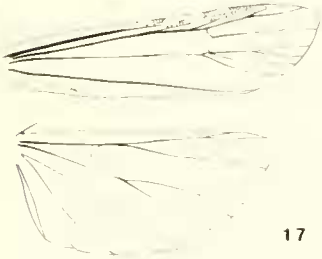
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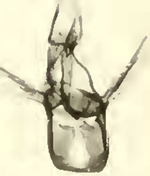
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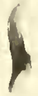
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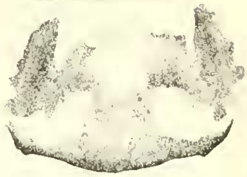
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Figs. 15–21. *Pseudocabotia balconiensis.* Fig. 15, Holotype ♀. Fig. 16, Paratype ♂, same locality as holotype, genitalia on slide ECK 160, E. C. Knudson coll. Fig 17, Wing venation of ♂ paratype, on slide AB 5363, Comal Co., Texas. Fig. 18, ♂ genitalia of paratype, on slide AB 3098, same specimen as Fig 17. Fig. 19, Aedeagus of ♂ paratype, on slide AB 3098, same specimen as Fig. 17. Fig. 20, Sclerotized 8th abdominal sternite, same slide and specimen as Fig. 17. Fig. 21, ♀ genitalia of holotype. Segments = 1.0 mm except Fig. 20 = 0.5 mm.

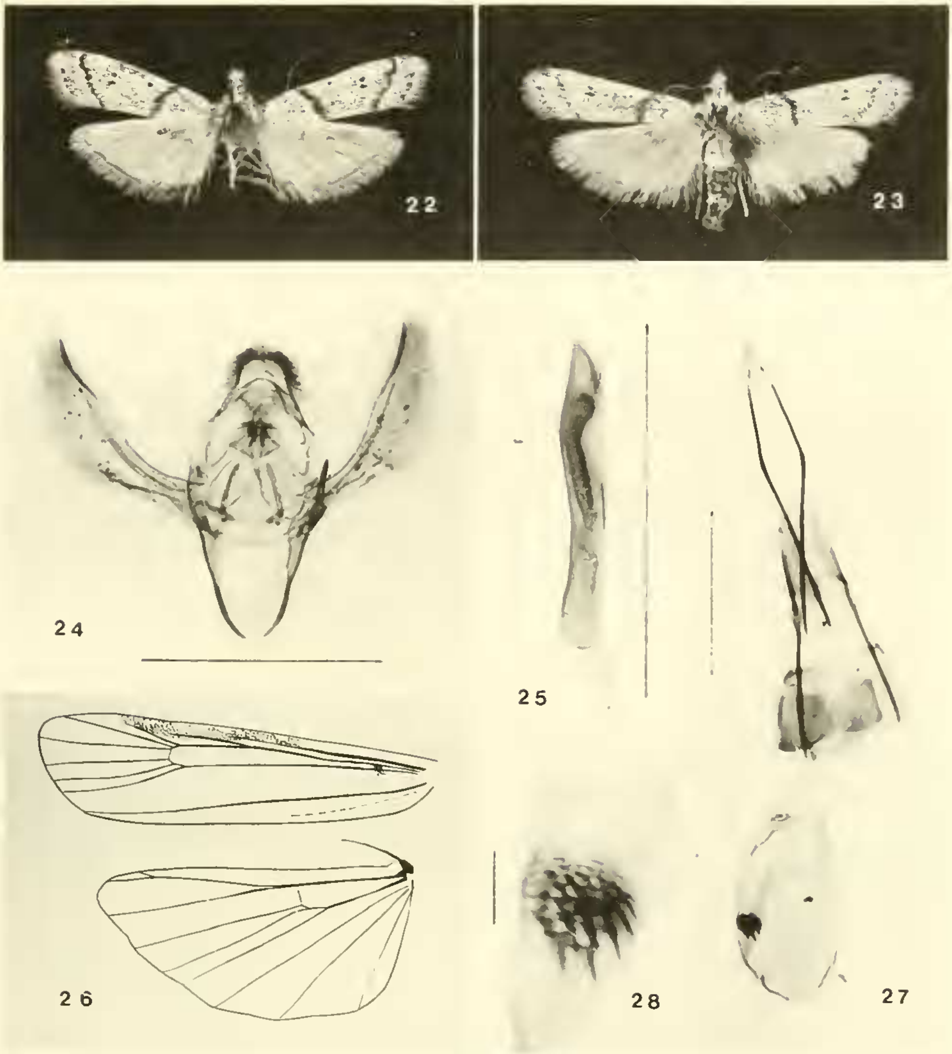
12-III-72, 1 ♂, genitalia slide AB 3098, wing venation AB 5369, collected by A. & M. E. Blanchard.

Remarks.—This new species is known only from areas adjacent to the upper Guadalupe River on the Edwards plateau in central Texas. The name of the species refers to the Balconian biotic province where it occurs. The female was selected as holotype because of its distinctive genitalia.

Homoeosoma parvalbum **Blanchard & Knudson, New Species**

Figs. 22–28

Description.—*Head:* Front pale fuscous; vertex white. Labial palpi upcurved, ascending to slightly above vertex, whitish ventrally and medially, light fuscous laterally. Maxillary palpi filiform, whitish. Antennae pale fuscous, lightly pubescent in male. *Thorax:* Whitish with a few scattered black scales. *Abdomen:* Whitish, shining. *Forewing:* Ground color white with evenly distributed peppering of black scales. Antemedial line prominent, black, angled outwardly from costa at basal ⅙ to dorsal margin at basal ⅓. Discal spots separate, black. Postmedial line well defined, black, parallel to termen. Terminal line indicated by 4 or 5 black dots from just above tornus, to beyond mid-termen, but not reaching apex. Fringe pale fuscous. *Hindwing:* Whitish, with fuscous terminal band. Fringe whitish, with



Figs. 22–28. *Homoeosoma parvalbum.* Fig 22, Holotype ♂. Fig. 23, Paratype ♀, Dugout Wells, Brewster Co., Texas. Fig. 24, ♂ genitalia, aedeagus removed, of holotype, from slide ECK 851. Fig. 25, Aedeagus of holotype, from slide ECK 851. Fig. 26, Wing venation of paratype ♂, on slide AB 2776, same data as Fig. 23. Fig. 27, ♀ genitalia of paratype, Rio Grande Village, Brewster Co., Texas, on slide ECK 861. Fig. 28, Much enlarged signum from same slide as Fig. 27. Segments = 1.0 mm except Fig. 28 = 0.1 mm.

darker median band. *Wing venation* (Fig. 26): Forewing with 9 veins, M_2 and M_3 united, venation otherwise like other species of *Homoeosoma* Curtis. *Length of forewing:* Male: (N = 1), 7.4 mm. Females: (N = 8) 6.6–7.4 mm, average 6.9 mm. *Male genitalia* (Figs. 24–25): Uncus broadly rounded. Gnathos triangulate, produced to sharp points at apical and lateral processes. Vinculum with small lateral arms. Aedeagus (Fig. 25), with vesica scobinate, without cornuti. Eighth abdominal segment without scale tufts, sternite with small median thornlike process.

Female genitalia (Figs. 27–28): Papillae anales unsclerotized; ostium bursae simple, unsclerotized; ductus bursae membranous; corpus bursae membranous, with signum (Fig. 28), a patch of thornlike spines.

Holotype (Fig. 22).—♂, Brewster Co., Texas, Big Bend Nat'l. Park, Hot Springs, 4-IV-84, genitalia on slide ECK 851, collected by E. C. Knudson and deposited in the National Museum of Natural History. Paratypes.—All from Big Bend Nat'l. Park, Texas. Dugout Wells, 13-IX-71, 1 ♂, 3 ♀; K-Bar Research Station, 16-IX-71, 1 ♀; Chihuahuan Desert near Nugent Mt., 17-IX-71, 1 ♀; all collected by A. & M. E. Blanchard. Rio Grande Village, 6-IV-84, 3 ♀, collected by E. C. Knudson.

Remarks.—This new species differs from all other species of *Homoeosoma* in the forewing venation, in which M_2 and M_3 are united, rather than stalked. This proved constant in two wing preparations. Since all the other characters of the insect including both male and female genitalia are like those of *Homoeosoma*, it did not seem necessary to create a new genus, based only on a minor venational difference. The small size and conspicuous maculation should also serve to distinguish this species from all other North American species of *Homoeosoma*. The male genitalia are most similar to *Homoeosoma imitator* Heinrich, but differ in the shorter, more broadly rounded uncus, and the more elongate, tapered vinculum. The female genitalia are hardly distinguishable from other species with unsclerotized papillae anales.

ACKNOWLEDGMENTS

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PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 239–251

MORIBAETIS: A NEW GENUS OF NEOTROPICAL BAETIDAE (EPHEMEROPTERA)[1]

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Abstract—A new genus, ***Moribaetis***, erected for four species of Neotropical Baetidae, including *M.* ***ellenae*** (Mayo), new combination; *M.* ***maculipennis*** (Flowers), new combination; *M.* ***salvini*** (Eaton), new combination, and *M.* ***macaferti*** Waltz, new species. The subgenus ***Mayobaetis*** is proposed to include *M. ellenae*, whereas the remainder of the known species are placed in the subgenus *Moribaetis* s.s. Presumed but unassociated larvae of *M. salvini* (Eaton) are described and redescriptions of the larvae of *M. ellenae* and *M. maculipennis* are given. Keys to the four species in the larval stage and three species known as adults are provided, and new distribution records are cited. Phylogenetic relationships of the cited species are proposed.

The study of Central and South American collections of mayflies for the analysis of the generic relationships within the family Baetidae has led to the discovery of several new taxa. One of these taxa is described below as a new genus. Not only is this new genus morphologically striking, primarily because of its relatively large size and unique larval claw and gill structure, but its species demonstrate a biological trait apparently unique among baetids. Larvae are splash-zone dwellers that are frequently found exposed on wet surfaces above the water line of tropical streams. Further notes on biology and species relationships follow the generic and species descriptions.

Moribaetis **Waltz and McCafferty, NEW GENUS**

Type species: Baetis maculipennis Flowers, 1979: 187.

Adult diagnosis.—Adults will key to couplet 36 in Edmunds et al. (1976) as *Baetis*. Species of *Moribaetis* may, however, be distinguished from other known Baetidae by the following combination of characters: 1) a body length of 10–12 mm; 2) short-stalked turbinate eyes; 3) brown infuscations in male forewing (as in Fig. 43); 4) cubitoanal cells often with three or four marginal intercalaries; 5) paired marginal intercalaries shorter than cell width (Fig. 13) to often exceeding cell width (Fig. 43) by at least one member of the pair; 6) hindwings present with two or three veins and costal process; and 7) male genitalia of modified *intercalaris*-type (sensu Needham et al., 1935).

Larval diagnosis.—Larvae of *Moribaetis* will key to couplets 41 and 42 in Edmunds et al. (1976) as *Baetis*, from which they may be distinguished by the

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following combination of characters: 1) a peculiar claw structure (Fig. 40) with one to three stout unpaired subapical setae that are distinctly different than paired subapical setae discussed by Morihara and McCafferty (1979) and Corkum and Clifford (1981); 2) a relatively large body size of 9–12 mm; 3) deflected antennae; 4) a labrum that is basally narrowed (Figs. 6, 15, 25, 34) and with long plumose marginal setae; 5) a hypopharynx with a broadened and tongue-like lingua and without a dorso-median tuft of setae; 6) the presence of a pigmented anteromedial membrane of the abdominal terga that appears as a dark posteromedial border of the preceding tergum; 7) abdominal terga with rectangulate-based, broadly pointed scales; 8) asymmetric gills with gill 1 smallest (subequal to other gills in final instar); and 9) the presence of a well-developed median terminal filament.

Etymology.—Masculine gender. *Moribaetis* is named in recognition of Dennis Morihara for his revisionary contributions to the systematics of Baetidae.

Subgenus *Mayobaetis* Waltz and McCafferty, New Subgenus

Type species: Baetis ellenae Mayo, 1973: 285.

Adult male.—Body 10–11 mm long. Forewing (Fig. 13) with paired marginal intercalaries shorter than the marginal cell width. Hindwing (Fig. 14) with 2 longitudinal veins; 2nd vein not forked; costal margin with process; intercalaries and crossveins few or absent. Forceps with terminal segment elongate and ovoid.

Adult female.—Similar to male except body sometimes more darkly pigmented and wings may not always be pigmented.

Mature larva.—Head capsule round in frontal view (Fig. 1). Antenna subequal to head in length; pedicel and scape (Fig. 11) with longitudinal row of fine setae on outer margin, strongly dorso-ventrally flattened (pedicel broadened), with dorsal side having large blunted scale-like tuberculations. Labrum (Fig. 6) without basal-medial raised area. Mandibular denticles (Fig. 8) of outermost incisor group distinct. Maxillary palp (Fig. 9) often with indication of 3rd segment. Prothorax without coxal osmobranchia. Median terminal filament less than or subequal to ½ length of cerci.

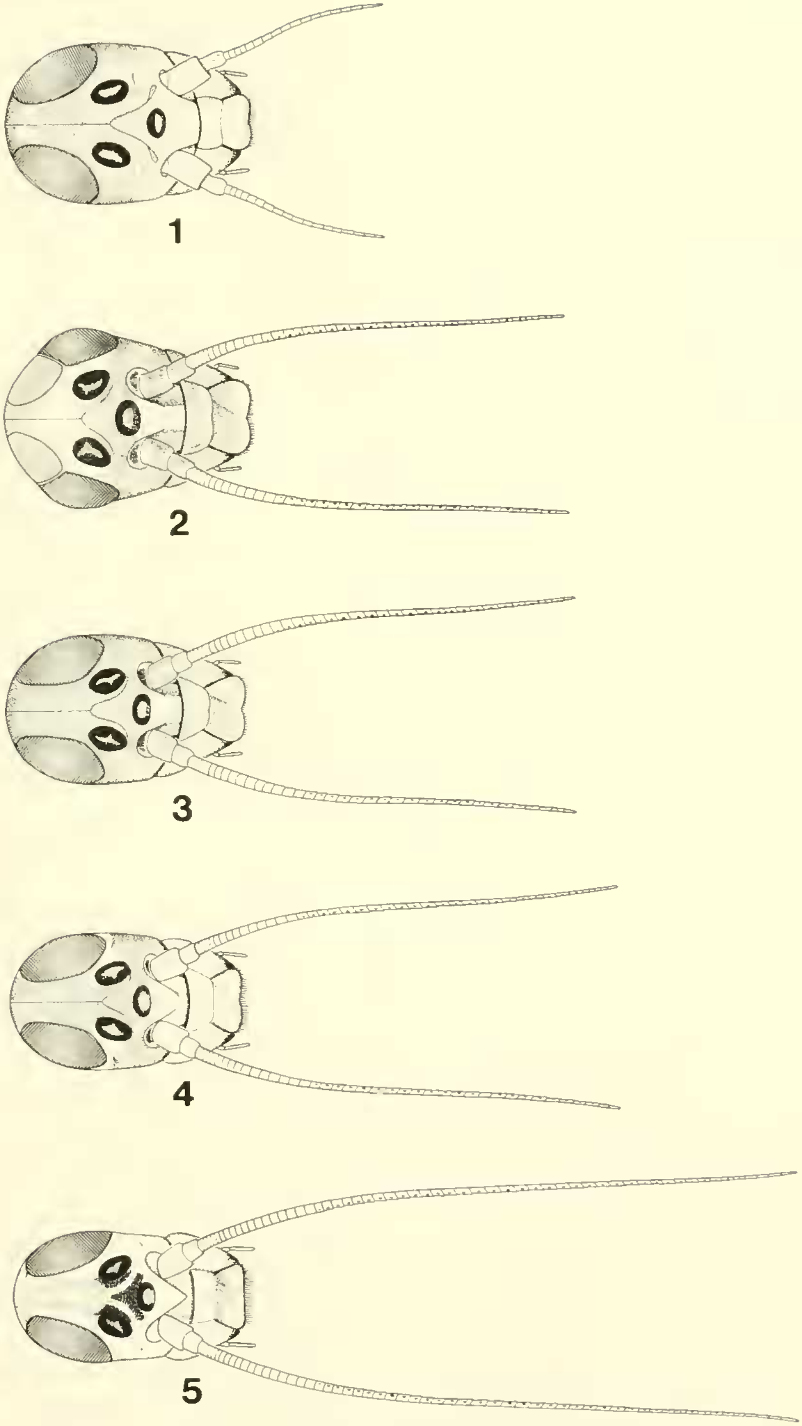
Etymology.—Masculine gender. This subgenus is named in honor of the ephemeropterist Mrs. Velma Knox Mayo.

Moribaetis (*Mayobaetis*) *ellenae* (Mayo), New Combination

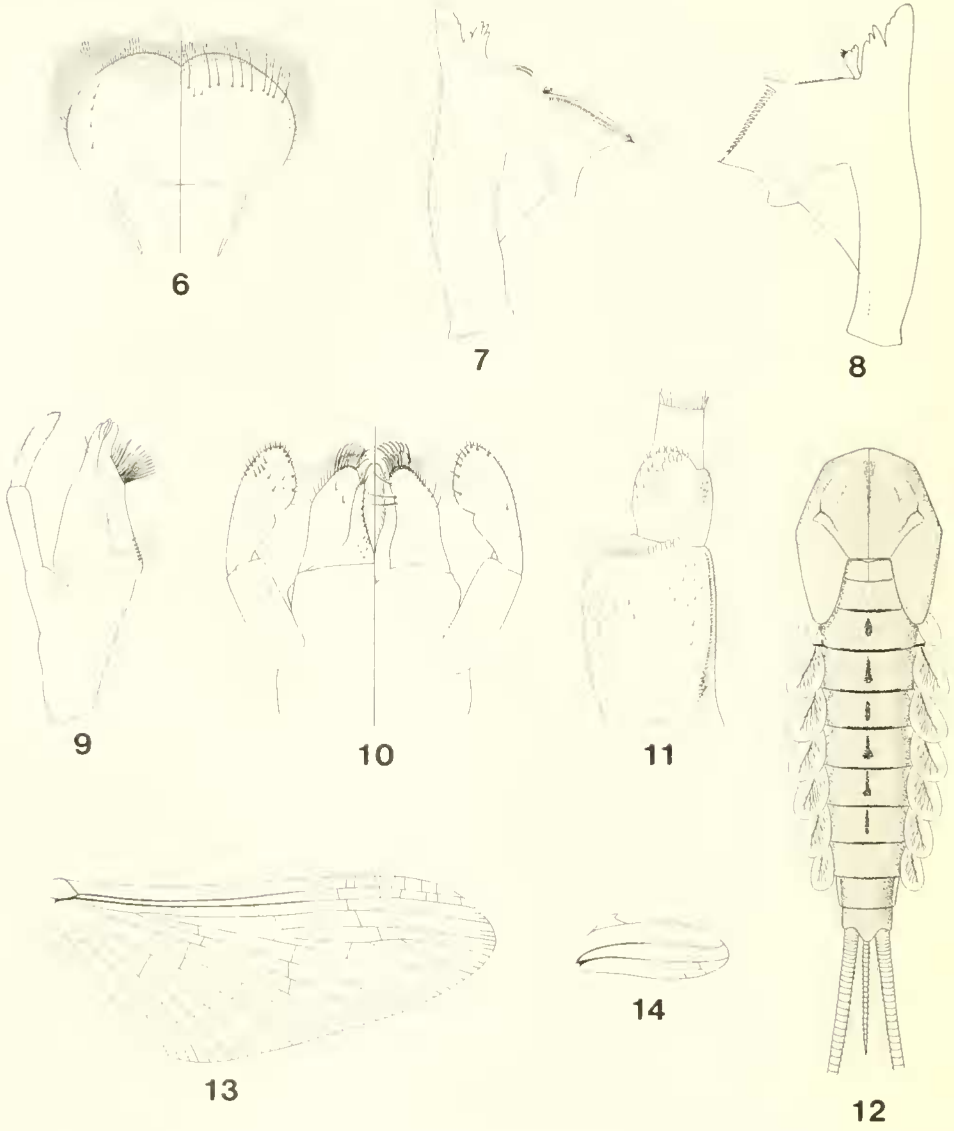
Baetis sp. 1 Roback, 1966: 137.
Baetis ellenae Mayo, 1973: 285; Berner, 1980: 190.

Adult male.—Adequately characterized by Mayo (1973).

Mature larva.—Head capsule (Fig. 1) rounded, uniformly colored. Antennae subequal to length of head capsule; pedicel ca. ½ length of scape; both scape and pedicel (Fig. 11) dorsoventrally flattened with scales, fine setae, and scale-like tuberculations and with longitudinal row of fine setae on outer margin; flagellum with subapical scales dorsally and clumped setae ventrally. Labrum (Fig. 6) with rounded anterior margins, strongly narrowed basally, without basomedian raised area, and with submarginal setae 1+9–10. Mandible (Figs. 7, 8) with divided incisors joined basally; prostheca of right mandible slender, bifurcate; thumb of left mandible elongate, narrow. Maxilla (Fig. 9) with palp exceeding galea-lacinea, and often with indication of 3rd segment. Segment 2 of labial palp (Fig. 10)



Figs. 1–5. *Moribaetis* larval head capsules (females). 1, *M. ellenae*. 2, *M. macaferti* (Guatemalan male). 3, *M. macaferti*. 4, *M. salvini*. 5, *M. maculipennis*.



Figs. 6–14. *Moribaetis ellenae.* 6, Labrum (left-ventral; right-dorsal). 7, Right mandible, ventral. 8, Left mandible, ventral. 9, Maxilla. 10, Labium (left-ventral; right-dorsal). 11, Antennal scape and pedicel (right side, dorsal view). 12, Dorsal color pattern. 13, Forewing, male imago. 14, Hindwing, male imago (not to scale).

subequal to segment 3; paraglossa with 3 apparent rows of apical setae; glossa with broadened (scraper type) setae and spine-like stout setae medially.

Diagnosis.—Larvae of *M. ellenae* may be separated from other species of this genus by the apically divided mandibular incisors (Figs. 7, 8); distinctive color pattern of the abdomen (Fig. 12); short stout antennae (Fig. 1); labial palp (Fig. 10) with segments 2 and 3 subequal; and a relatively round anterior margin of the labrum (Fig. 6). Adults of this species may be distinguished by a hindwing venation that consists of two veins with the second undivided (Fig. 14) and by the elongate terminal segment of the male forceps.

Known distribution.—Ecuador (type), Peru, Costa Rica, from 1400 m to 2000 m.

Material examined.—♀ larva (Paratype): Ecuador, Macuchi, Catopaxi Prov., Rio Amayo, VI-30-1943, 6000 ft. elev., V. K. Mayo. One larva: Costa Rica, San Jose, 12 mi N San Isidro del Genekal (Pan Amer. Hwy.), 5200 ft. VII-20-1962. G. G. Musser.

Subgenus *Moribaetis* sensu stricto

Adult male. Body 10–11 mm long. Forewing (Fig. 43) with ano-cubital cells frequently with 3 or 4 marginal intercalaries; all intercalaries long, equal to ½ cell width or more. Hindwing (Fig. 44) with 3 longitudinal veins, 2nd vein forked in known species and with few crossveins and intercalaries. Forceps of genitalia with terminal segment small, ovoid to nearly spherical.

Adult female.—Similar to male except sometimes more darkly pigmented and wings may not always be pigmented.

Mature larva.—Head capsule round to elongate in frontal view (Figs. 2–5). Antennae (Figs. 2–5) variable in length; pedicel and scape moderately dorsoventrally flattened, without (Figs. 22, 30) scale-like tuberculations, and without longitudinal row of fine setae on outer margin. Labrum (Figs. 15, 25, 34) with basomedial raised area. Mandibular denticles (Figs. 16, 17) of outermost incisor group fused. Maxillary palp (Fig. 28) 2-segmented. Prothorax with short, stout coxal osmobranchia (Fig. 31). Median terminal filament ½ to subequal length of cerci.

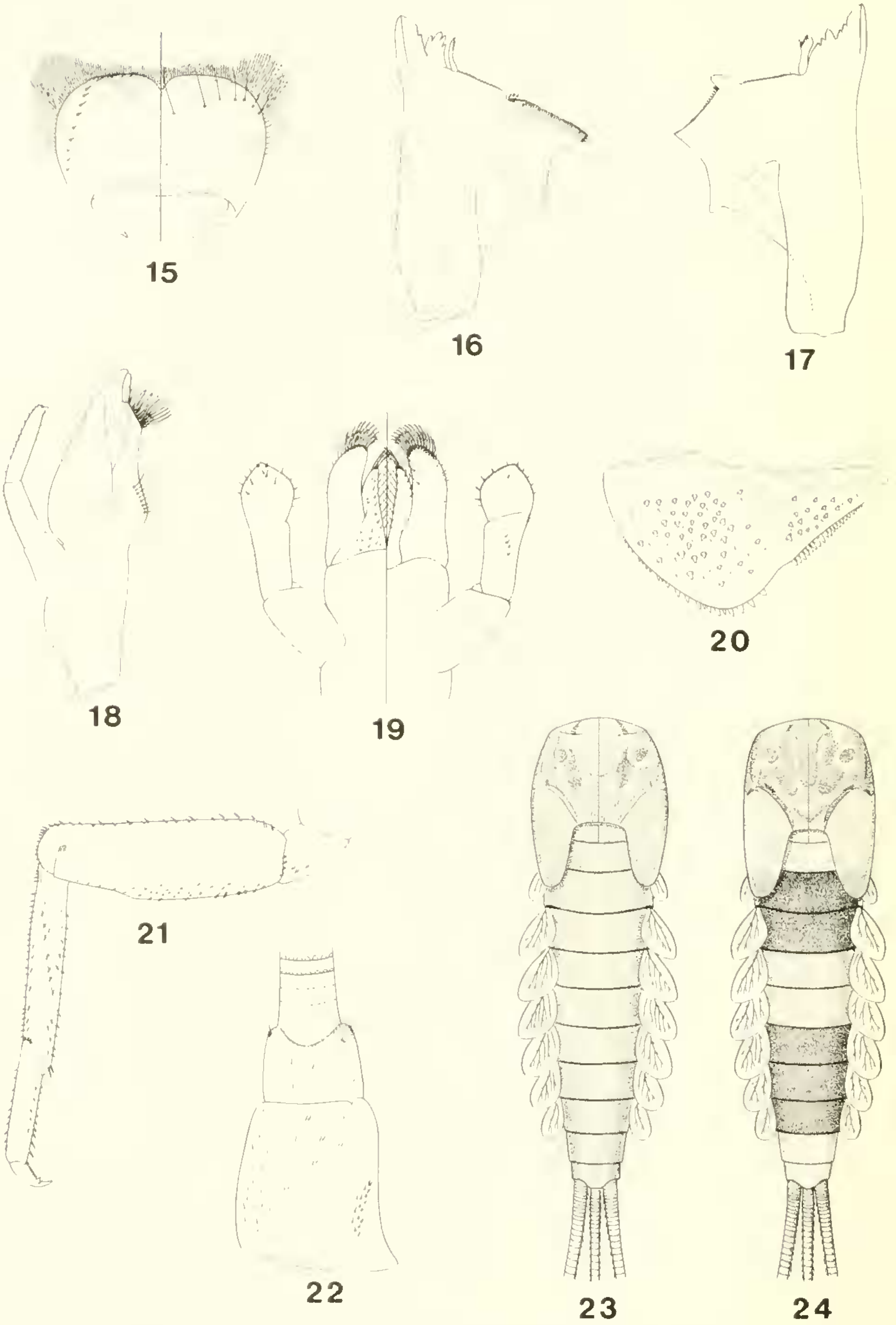
Subgeneric Diagnosis.—The two subgenera may be most easily distinguished as larvae by the following: the presence of procoxal osmobranchia (Fig. 31) [terminology after Shepard and Stewart (1983)] in *Moribaetis* versus none such in *Mayobaetis*; longer antennae relative to the head capsule (Figs. 2–5) in *Moribaetis* s.s. and a median terminal filament that is longer relative to the cerci in *Moribaetis* s.s.

The presence of three veins in the hind wing, the second of which is forked, in *Moribaetis* s.s. (Fig. 44) versus only two veins in *Mayobaetis* (Fig. 14), neither of which is forked; and a small spherical terminal genital forceps segment in *Moribaetis* s.s. versus an elongate, ovoid segment in *Mayobaetis*, will easily distinguish the known adults of the two subgenera.

Moribaetis (*Moribaetis*) *macaferti* Waltz, NEW SPECIES

Adult.—Unknown.

Mature larva.—Body 8–9 mm long. Cerci 4.5–5.0 mm long. Terminal filament 3.5–4.0 mm long. Head (Fig. 2) rounded, yellow-brown to tan, without darkening between ocelli. Antennae deflected downward, paler ventrally, moderately long, reaching gill 3 to 5; scape and pedicel (Fig. 22) with random fine setae and clumped setae; pedicel with subapical scaling. Labrum (Fig. 15) with raised basal median area, and with rounded anterior margin; 1 + 5–6 stout submarginal setae; marginal setae long and plumose; sublateral row of ventral spines increasing in size from base to margin. Mandible (Figs. 16, 17) with row of fine spine-like setae between prostheca and molar area, outermost incisor denticles fused (few denticles may



Figs. 15–24. *Moribaetis macaferti.* 15, Labrum (left-ventral; right-dorsal). 16, Right mandible, ventral. 17, Left mandible, ventral. 18, Maxilla. 19, Labium (left-ventral; right-dorsal). 20, Paraproct. 21, Fore leg. 22, Antennal scape and pedicel (right side; dorsal view). 23, Dorsal color pattern. 24, Dorsal color pattern, Guatemalan male.

be discernible on margin), and innermost incisor tridentate or quadridentate, fused apically with outermost incisor on left mandible, free apically from outermost incisor on right mandible; thumb of left mandible broadly triangulate and blunt. Maxillary palp (Fig. 18) 2-segmented, subequal to galea-lacinea in length. Segment 3 of labial palp (Fig. 19) bulbous; segment 2 ca. 2–3× length of segment 3, with weak inner apical lobe and 4 dorsal setae; paraglossa with 3 apical rows of setae. Thorax tan and lacking medial stripe dorsally; procoxal osmobranchia present. Legs cream to tan, setation as in Fig. 21, tibia and tarsus uniformly colored, with spine-like setae and fine setae on dorsal and ventral margins; claws with 8 to 10 denticles and a strong subapical seta. Abdominal terga (Fig. 23) uniformly colored, without distinct patterning; posterior tergal margins with sharp spines. Gills asymmetric, with sclerotized anterior and posterior margins, and distinct tracheae; anterior margin serrate, with fine setae between serrations. Paraproct as in Fig. 20. Cerci and median terminal filament uniformly colored.

Variant.—A single larva from Guatemala possesses a unique color pattern (Figs. 2, 24) but is structurally identical with other specimens of *M. macaferti*.

Diagnosis.—*Moribaetis macaferti* may be distinguished from other species of this genus by the combination of characters as follow: shape of the mandibles (Figs. 16, 17) with distinctly denticled innermost incisors, right innermost incisor free apically from outermost incisor, left innermost incisor fused apically to outermost incisor; segment 2 of labial palp (Fig. 19) ca. 2–3× length of segment 3, and with four dorsal setae; paraglossa with three apical rows of setae (Fig. 19); submarginal row setal pattern of 1+5–6 stout setae on labrum (Fig. 15); antennae reaching gill 3 to 5 (Figs. 2, 3); and frons without medial pigment spot between ocelli. Adults are unknown.

Type material.—Holotype larva: Costa Rica, Guanacaste Pro., Rio Tenorio at Finca La Pacifica, E of Pan Amer. Hwy. II-2-1969. W. P. McCafferty, deposited in the Purdue University Entomological Research Collection. Three larval paratypes: same data and deposition as holotype, with one whole-mount slide preparation (3 slides), Hoyer's medium (water). One larval paratype: Guatemala, Escuiutla, VI-15-1962, G. G. Musser, with leg and mouthparts slide mounted in euparal (abs. alc.), deposited in the University of Utah Collections.

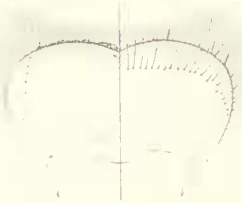
Etymology.—The specific epithet is a phonetic spelling of the collector's last name, McCafferty.

Moribaetis* (*Moribaetis*) *maculipennis (Flowers), New Combination

Baetis maculipennis Flowers, 1979: 187.

Adult male.—Adequately characterized by Flowers (1979).

Mature larva.—Antennal scape (Fig. 30) subequal to pedicel in length, with scales, clumped setae, and random fine setae; flagellum with dorsal scales and ventral clumped setae. Labrum (Fig. 25) truncate apically, narrowed basally with prominent basal median raised area, and with submarginal setae 1+12–20. Mandible (Figs. 26, 27) with fine spine-like setae between prostheca and molar area; incisors of left mandible completely fused into single blade-like structure, innermost incisor of right mandible discernible as a smaller secondary blade near prostheca; prostheca slender, ribbonlike with apical furcations. Maxillary palp (Fig. 28) subequal to galea-lacinea in length, 2-segmented; galea-lacinea relatively



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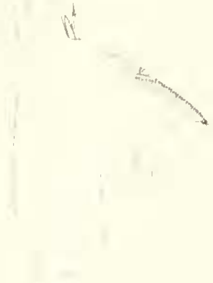

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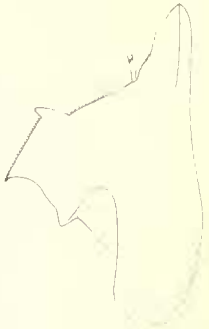

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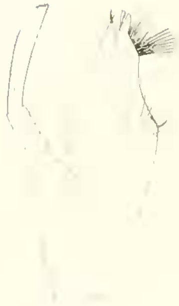

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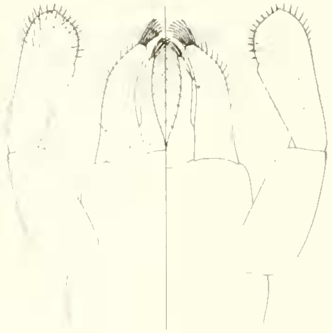

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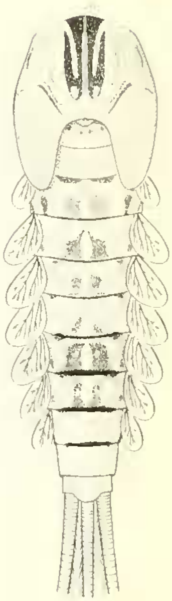

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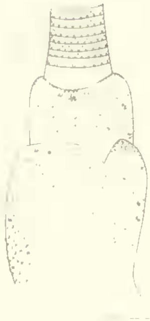

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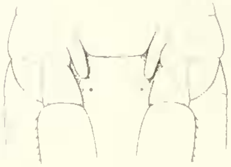

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Figs. 25–33. *Moribaetis maculipennis*. 25, Labrum (left-ventral; right-dorsal). 26, Right mandible, ventral. 27, Left mandible, ventral. 28, Maxilla. 29, Labium (left-ventral; right-dorsal). 30, Antennal scape and pedicel (right side; dorsal view). 31, Prothorax ventral, procoxal osmobranchia. 32, Dorsal color pattern. 33, Male imago cercus (basal).

slender. Segment 2 of labial palp (Fig. 29) 2.5–3.0× length of segment 3 and with 6 or 7 dorsal setae; paraglossa with 2 apparent rows of apical setae; glossa narrowed, with serrate setae apically and long fine setae medially. Procoxal osmobranchia present (Fig. 31).

Diagnosis.—Larvae of *M. maculipennis* may be easily separated from other species of this genus by the distinctive abdominal color pattern (Fig. 32); the highly fused mandibular incisors forming a single blade (Figs. 26, 27), the relative second segment lengths and relation of the labial palp (Fig. 29); the relatively long antennae that may reach gill 7; and the distinct medial spot located on the frons (Fig. 5). Adults of this species may be recognized by the hindwing venation that includes a forked second vein with relatively few intercalaries within the fork; the abdominal color pattern; and cerci with an alternating pattern of one white segment then three darkened segments (Fig. 33).

Known distribution.—Costa Rica, Panama (Type).

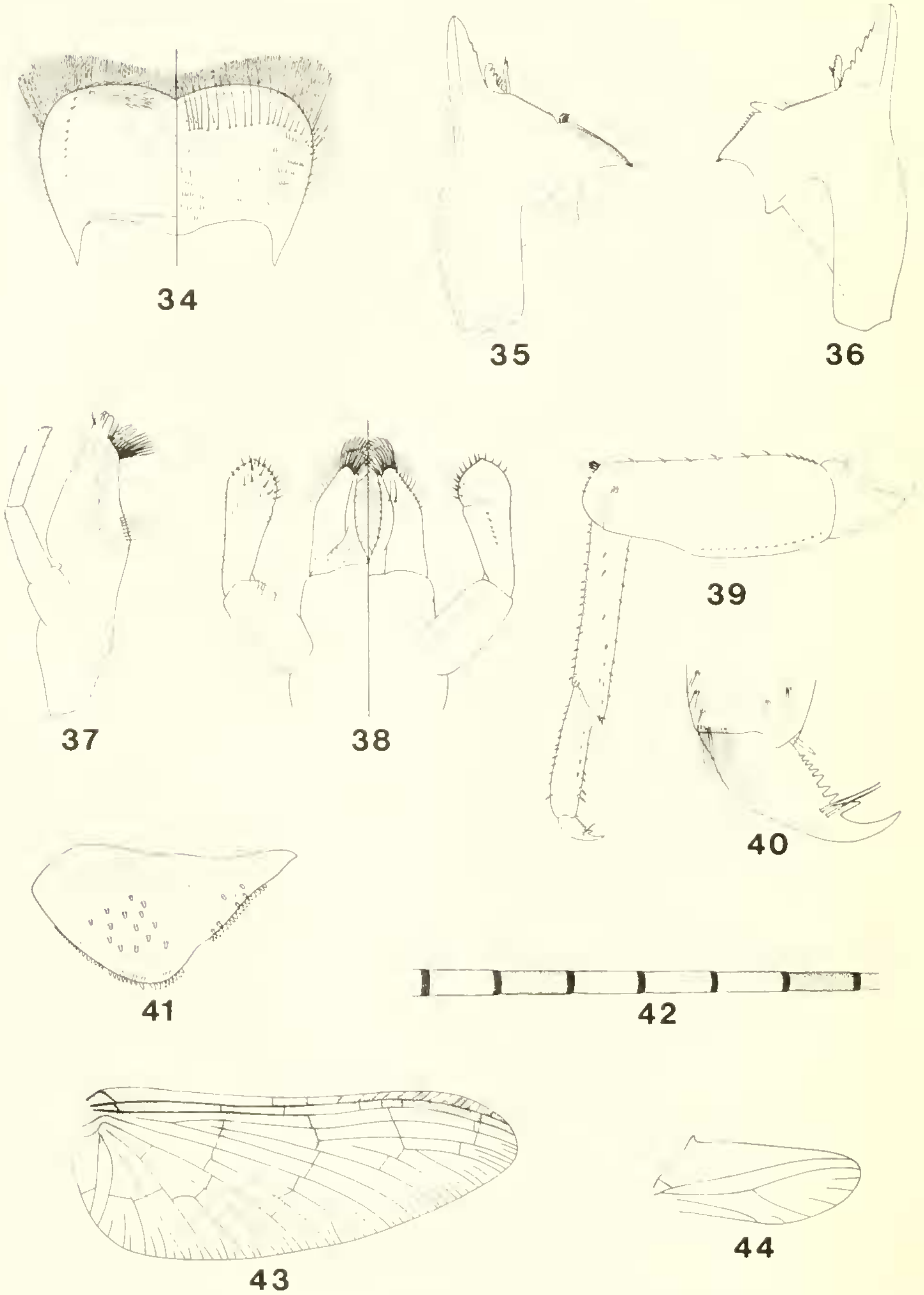
Material examined.—♂ adult paratype: Panama, Chiriqui, Fortuna, 8°44′N: 82°15′W. VI-8/14-1977 (light trap). Henk Wolda. Numerous larvae: Costa Rica, San Jose, 12 mi N San Isidro del Genekal (Pan Am. Hwy.) 5200 ft. elev. VIII-20-1962; G. G. Musser. Puntarenus Pro., 10 km N of San Vita at quarry waterfall, III-16-1969, W. P. McCafferty. Coniago, Moravia, 1116 m elev. VI-24-1962, G. G. Musser.

***Moribaetis* (*Moribaetis*) *salvini* (Eaton), New Combination**

Baetis salvini Eaton, 1885: 170; 1892: 13; Kimmins, 1934: 347; 1960: 289; Edmunds et al., 1976: 164.

Adult male.—Adequately characterized by Eaton (1885).

Mature larva.—Larvae that appear to match the adult color pattern of *M. salvini* and that fit the classification scheme concordant with the relationship of *M. salvini* to that of *M. maculipennis* are described as *M. salvini* as follows: Body 8–9.5 mm long. Head capsule (Fig. 4) elongated; yellow-brown to tan, vertex darker, without darkening between ocelli. Antenna deflexed, paler ventrally, 3× length of head capsule, reaching gill 3 to 5; scape and pedicel (as in Fig. 30) with clumped fine setae and random fine setae; pedicel with subapical scaling. Labrum (Fig. 34) with raised basal median area, with anterior margin slightly more projecting than in *M. maculipennis* and with submarginal setal pattern 1+7–9 (not including lateral field setae); marginal setae long, plumose; sublateral row of ventral spines 8–10. Mandible (Figs. 35, 36) with row of fine spine-like setae between prostheca and molar area, with outermost incisor denticles fused (few denticles may be discernible on margin), and with innermost incisor tridentate, fused apically with outermost incisor on left mandible, and free apically from outermost incisor on right mandible, thumb of left mandible elongate and blunt. Maxillary palp (Fig. 37) 2-segmented, subequal to galea-lacinea in length. Segment 3 of labial palp (Fig. 38) bulbous; segment 2 with weak inner apical lobe and 6 to 8 dorsal setae; paraglossa with 2 apical rows of closely set setae. Thorax tan, with medial stripe on pro- and mesonotum (as in Fig. 32); procoxal osmobranchia present. Legs cream colored and with setation as in Fig. 39; tibia and tarsus jointly graded from cream to tan distally, with spine-like setae dorsally and ventrally; claws (Fig. 40) with 8 or 9 denticles and 1 to 3 stout subapical seta(e) reaching apex. Abdominal tergal pattern with distinct lateral oblique bars; medial areas of terga with broken pigmented pattern similar to *M. maculipennis*; posterior margins of terga with sharp scales. Gills asymmetric, with sclerotized anterior and posterior margins, and distinct tracheae; apical margin serrate with several fine setae between teeth;



Figs. 34–44. *Moribaetis salvini.* 34, Labrum (left-ventral; right-dorsal). 35, Right mandible, ventral. 36, Left mandible, ventral. 37, Maxilla. 38, Labium (left-ventral; right-dorsal). 39, Foreleg. 40, Foreclaw. 41, Paraproct. 42, Male imago cercus (basal). 43, Forewing, male. 44, Hindwing, male (not to scale).

gill on segment one smaller than those on remaining segments. Paraproct (Fig. 41) with sharp marginal denticles, not clustered apically, and with surface having fine setae and clumped setae. Cerci and median terminal filament unicolored.

Diagnosis.—Larvae of *M. salvini* may be separated from other species of the genus by the antennal length that reaches to gill 3–5 (Fig. 4); form of the mandibles (Figs. 35, 36), with distinctly denticled innermost incisors; frons without pigment spot between ocelli (Fig. 4); paraglossae with two apical rows of setae (Fig. 38); and paraproct (Fig. 41) denticles not clustered apically. Adults of *M. salvini* may be distinguished by the forked second vein of the hindwing (Fig. 44) with several relatively prominent marginal intercalaries; color pattern of the abdomen; and cerci (Fig. 42) of adult male, that have one darkened segment alternating with three light-colored segments.

Known distribution.—Costa Rica (type), Guatemala(?).

Material examined.—Lectotype male adult: Costa Rica: Volcan de Irazu, 6000 to 7000 ft. H. Rogers. Female adult: Guatemala: Panima, Vera Paz, no date, det. A. E. Eaton [Identification of this specimen is questionable]. Larvae: Costa Rica, San Jose. 12 mi N San Isidro del General, (Pan Amer. Hwy.) 5200 ft. VIII-20-1962, G. G. Musser. One male adult specimen in relatively poor condition that we have examined from Huatusco, Vera Cruz Pro., Mexico, agrees with the type in abdominal maculation pattern and hindwing venation but lacks other characters (especially of cerci and legs) that are found in other known adults of this species.

KEY TO MALE ADULTS OF *MORIBAETIS* SPECIES

1. Hindwing with two longitudinal veins (Fig. 14); forewing with little mottling; abdominal terga patterned on posterior margin with black-brown on either side of midline and laterally near pleural fold; terminal segment of forceps elongate-ovoid .... *M. ellenae*
– Hindwing with three longitudinal veins (Fig. 44); forewing patterned; abdominal terga with varied color patterns; terminal segment of forceps spherical, small 2
2. Hindwing with marginal intercalaries reduced, usually with one distinct intercalary and two minor intercalaries; cerci (Fig. 33) banded in alternating pattern of one white segment with three darkened segments .... *M. maculipennis*
– Hindwing with marginal intercalaries more apparent, usually with two distinct intercalaries and two or three minor intercalaries (Fig. 44); cerci (Fig. 42) banded in alternating pattern of one lightly darkened segment with three white segments .... *M. salvini*

KEY TO MATURE LARVAE OF *MORIBAETIS* SPECIES

1. Antennae short, subequal to head capsule in length (Fig. 1); segment 2 of labial palp subequal in length to segment 3 (Fig. 10); procoxal osmobranchia absent; median terminal filament less than or subequal to one-half length of the cerci; abdominal color pattern as in Fig. 12 .... *M. ellenae*
– Antennae distinctly longer than head capsule; segment 2 of labial palp longer than segment 3; procoxal osmobranchia present (Fig. 31); median terminal filament greater than or subequal to one-half length of cerci; abdominal color pattern varied 2

2. Incisors of mandible fused into one blade-like structure lacking denticles (Figs. 26, 27); antennae often reaching or surpassing gill 6 or 7; color pattern as in Fig. 32; frons with distinct medial pigmented area between ocelli (Fig. 5) .... *M. maculipennis*
– Incisors of mandible with easily discernible denticles (Figs. 16, 17 and 35, 36); antennae reaching gill 3 to 5; frons without medial pigmented area 3
3. Paraglossa (Fig. 19) with three apical rows of setae; segment 2 of labial palp with four dorsal setae (Fig. 19); abdominal terga without distinct color patterning (Figs. 23, 24) .... *M. macaferti*
– Paraglossa (Fig. 38) with two apical rows of setae; segment two of labial palp with six dorsal setae (Fig. 38); abdominal terga with distinctive color pattern similar to Fig. 32 .... *M. salvini*

SPECIES RELATIONSHIPS

It is difficult at this time to determine the derivation of *Moribaetis* and therefore have use of the appropriate outgroup comparison for deciphering character state polarity. Nonetheless, certain evidence appears to support convincingly the relationships described below.

The common possession of procoxal osmobranchia and a labrum with a uniquely elevated basal medial area in *M. macaferti, M. maculipennis,* and *M. salvini* strongly suggests a synapomorphy tying these species (subgenus *Moribaetis*) to a common branch separate from a *M. ellenae* lineage (subgenus *Mayobaetis*). The short antennae of *M. ellenae,* among other character states, would appear to be an autapomorphy. Within the subgenus *Moribaetis,* the extremely reduced apices of the paraglossae and two apical rows of paraglossal setae of *M. maculipennis* and *M. salvini* would indicate that these species form a sister group on a branch separate from the *M. macaferti* lineage.

The above relationship predicts the polarity of other character states within the genus and indicates a number of possible evolutionary trends. These include the fusion of the mandibular incisors and independently a fusion of the denticles of the incisors, both lengthening and shortening of the antennae, increase in the distribution and intensity of abdominal pigmentation, elongation of the clypeus, narrowing of the intraantennal frontal process, and an increase in the size of the medial basal region of the labrum (possibly in conjunction with increased musculature). Furthermore these deductions may allow the origin of the genus to be hypothesized once more information on related baetid genera is available.

BIOLOGY

On the basis of collections taken in Ecuador and reported by Mayo (1973), observations discussed by Peters (1973), and field notes by W. P. McCafferty, the species of this genus frequent the upper surfaces of rocks in fast water, the bases of waterfalls in the splash zone, or rocks along the shoreline of fast-water areas. Peters (1973) states that the Peruvian baetid (*M. ellenae*?) he observed "could be found on the top of rocks instead of in the water." Peters also reported that when disturbed, the larvae would flip into the air up to 3 feet and escape into the water. Riek [see ref. Peters (1973)] and Edmunds et al. (1976) have also noted a similar phenomenon in species of Siphlonuridae.

The species of *Moribaetis* have sympatric distributions in Central America. Three of the species (*M. maculipennis, M. salvini,* and *M. ellenae*) have been collected together. Differences in habitat partitioning that may be attributed to specific mouthpart structure differences and possible related feeding behavior are at present unknown.

ACKNOWLEDGMENTS

We thank the following for the loan of material: G. F. Edmunds, Jr., University of Utah; W. Flowers, Florida A&M; D. Morihara, Maui, Hawaii; I. Müller-Liebenau, Max-Planck Institute, Plön; M. Pescador, Florida A&M; and P. C. Barnard, British Museum of Natural History, London, for loan of the lectotype of *Baetis salvini* Eaton and a Guatemalan *Moribaetis* female. We also thank A. V. Provonsha for illustrations.

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BOOK REVIEW

Eriophyid Mites of Alfred Nalepa. By Richard Albert Newkirk. Thomas Say Foundation Publications, Entomological Society of America, College Park, Maryland. Volume 9, 137 pp., 1984. $20.00, ESA Members $12.00.

Alfred Nalepa's eriophyoid publications covered a span of 43 years, beginning in 1886 and ending with his death in 1929. His last paper was published posthumously in 1930. Nalepa described 331 species, 42 varieties, and 28 subspecies. His works appeared under 113 separate titles. Nalepa was the dominating eriophyoid worker during his period, and today he is considered the "Founder of Eriophyidology."

Those who are involved in the systematics of eriophyoids know that studying Alfred Nalepa's works has been an avocation for Richard Albert Newkirk for many years. Thanks to E. W. Baker's encouragements, Newkirk has completed and published his studies in a highly academic paper.

Newkirk's book is divided into an introduction, format, acknowledgment, synopsis of Nalepa's works, host list, bibliography, index of plant names, and index of eriophyoid names.

The section on synopsis of Nalepa's work is possibly the most important to eriophyidologists. It is here that one finds Nalepa's eriophyoid works presented under 113 titles given in full. The titles are in chronological order, with a few noted exceptions. Under each title, the genera are arranged alphabetically with type species fixation for genera proposed by Nalepa. Under the genera, the species names are arranged alphabetically, followed by literature citation, host plant, changes in rank, emendations, errors, misidentifications, nomina nuda, preoccupied names, and synonyms.

In the section on host list, the plant taxa are arranged in a phylogenetic system similar to that employed by Nalepa in his 1929 "Katalog." Newkirk could have made this section more useful by having information on the relationship of the mite to the host plant as did Nalepa in his "Katalog."

Other than a few errors in spelling, the book is well-done. It should be available to eriophyidologists and to systematists involved in the identification of eriophyoids. It should be in all libraries with collections of acarological works.

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NOTE

Observations on the Reproductive Behavior of Two Neotropical Robber Fly Species (Diptera: Asilidae)

Most ethological research on adult robber flies has centered on the predatory behavior of north temperate species. Here I present some observations on the reproductive behavior of two neotropical asilid species. All observations were made in 1981 within the forest of Barro Colorado Island, Panama. Complete geologic, climatic, and floristic descriptions of Barro Colorado are given in Croat (1978. Flora of Barro Colorado Island, 943 pp.).

OBSERVATIONS OF *SENOBASIS CORSAIR* BROMLEY

The genus *Senobasis* (subfamily Dasypoginae) includes 17 described species all of which are neotropical in distribution (Papavero, 1975. Arq. Zool. 26: 191–318). *Senobasis corsair* has previously been reported from Panama, Colombia, and Costa Rica (Papavero, loc. cit.), but published behavioral observations are completely lacking. Females are slightly larger than males; for 5 males and 5 females, the mean body lengths were 18.3 mm and 19.1 mm, respectively. Both sexes possess black legs, a black face, a predominately bluish-black mesonotum, and brown wings which produce violaceous reflections. However, the sexes differ with respect to abdominal color. With the exception of narrow whitish bands on tergites 2 and 3, the female's abdominal tergites are completely black. In males, on the other hand, only tergites 1 and 5–7 are black, while tergites 2–4 are completely white.

Matings were observed on four different occasions between May 3–May 14 and were similar in each instance. Courtship appears to be absent; in each case a flying male simply pounced upon a perching female, and copulation followed immediately. When foraging, both sexes typically perch on horizontal branches with their wings resting directly over the abdomen. When in the end-to-end position, however, only the female maintains this typical perching posture. After coupling with the female, the male hangs vertically (head downward) behind the female. The male grips the branch with all its legs and is further supported by the female's weight, which is shifted slightly forward during copulation. While in this vertical position, the male also holds each wing at approximately a 45° angle to the body thus exposing the white segments of the abdomen. Copulations lasted 50–135 min and were apparently terminated by the male who, in each case, suddenly disengaged and flew off.

For a male in copulo, the vertical position, the violaceous reflections of the wings, and the contrasting black and white tergites collectively create an unusual visual effect. As an initial hypothesis, I suggest that this visual effect may serve to confuse predators (e.g. birds) and thus reduce the risk of predation during the rather lengthy copulation. This lowered risk might result from either a predator's failure to recognize the mating pair as potential prey or a reduction in the speed and/or accuracy of an attempted capture. The validity of this "predator confusion" hypothesis, of course, still requires experimental verification.

Following one copulation, the female was captured, returned to the laboratory, and placed in a plastic container. Approximately 48 h later, eight eggs were found on a side of the container. The eggs were laid more or less end-to-end in a straight line, and adjacent eggs were firmly stuck together. The eggs were grayish-black, elongate ovals with an average length of 1.4 mm (range: 1.2–1.5) and an average width of 0.55 mm (range: 0.5–0.7). No surface ridges or sculpturing were apparent under a light microscope (430×). No hatching occurred after 7 days at which time the eggs were preserved. Although oviposition was not observed in the field, a female was seen walking slowly on bare ground for approximately 45 minutes. Her abdomen was held above ground during most of this time, but during 5 short intervals (5–15 s) she lowered the tip of her abdomen to the ground and moved it back and forth slowly over the surface. These 5 sites were examined and then excavated, but no eggs were found.

An Observed Oviposition and the Eggs of *Promachus anceps* Osten Sacken

Although *Promachus* is a large (approximately 250 species; Hull 1962) cosmopolitan genus, oviposition and eggs have been described for only a few species (Felt, 1915, N.Y. State Mus. Bull. 175: 24–26; Davis, 1919, Bull. Nat. Hist. Sur. Ill. 13: 53–138; Lavigne and Holland, 1969, Univ. Wyo. Agric. Exp. Stn. Sci. Monogr. 18: 1–61). *Promachus anceps* has previously been reported from Panama and Mexico (Osten Sacken, 1887, Biologia-Centrali Americana, pp. 167–213), but there are no published accounts of its biology. On June 23 at approximately 1045 h, a female was observed walking along a fallen, dead branch that was suspended about 2 m above ground by some other branches. Apparently searching for a suitable site, the female stopped frequently and "tested" the branch surface with her ovipositor. To do so, she curled the tip of her abdomen forward and made distinct probes while simultaneously moving it from side to side. After making 15–20 such "tests" (each lasting 2–3 s), she reached one end of the branch and, finding it hollow, turned around and inserted her curled abdomen into the opening. She remained in this position for approximately 30 s after which she flew off and was lost from view.

Examination of the stick revealed that, while no eggs were laid on the surface, 20 eggs had been deposited in the open end. The eggs were pale white, elongate ovals with an average length of 1.55 mm (range: 1.4–1.65) and an average width of 0.5 mm (range: 0.4–0.55). The eggs were arranged in two adjacent rows, and neighboring eggs were cemented together. The whole egg mass was 7.9 mm long and 0.9–1.1 mm wide (these latter values corresponding to the diameter of the hollow groove) and was 5.1 mm from the end of the stick. No surface ridges or sculpturing were apparent under a light microscope (430×). No hatching occurred after 13 days at which time the eggs were preserved.

I am grateful to E. Fisher for identifying the species.

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NOTE

Range Extensions and Ecological Data for Southern United States Ephemeroptera

While conducting ecological studies of southern rivers, I found six mayfly species beyond their previously known ranges. Since little or no ecological information exists for these species and the new state records better define range extremes, the following data are presented.

Anepeorus simplex (Walsh) (Heptageniidae): Arkansas, Jefferson County, Arkansas River near Pine Bluff. T.6S., R.7W., S.7. 15 May 1980. Previously known from Illinois, Iowa, and Georgia. *Baetis ephippiatus* Traver (Baetidae): Louisiana, Natchitoches Parish and Red River Parish line, Bayou Pierre near Evelyn. T.12N., R.10W., S.36. 21 Aug. 1979. Formerly reported from the extreme southeast, west to Alabama, and north to Indiana and Virginia. *Baetis longipalpus* Morihara and McCafferty: Louisiana, Red River Parish, Red River near Grand Bayou. T.13N, R.11W., S.2. 22 Aug. 1979. Indiana and Wisconsin were the only known localities. *Baetis quilleri* Dobbs: Louisiana, De Soto Parish and Red River Parish line, Bayou Pierre near Lake End. T.11N., R.9W., S.36. 22 Aug. 1979. Common to the extreme southwest. *Leptohyphes dolani* Allen (Tricorythidae): Florida, Hamilton County and Madison County line, Withlacoochee River near Pinetta. T.3N., R.10E., S.204,205. 13 Sept. 1979. Previously collected from Savannah River, Georgia. *Spinadis* sp. Edmunds and Jensen (Heptageniidae): Arkansas, Jefferson County, Arkansas River near Pine Bluff. T.6S., R.7W., S.7. 15 May 1980. This rarely collected genus was known from Georgia, Indiana, and Wisconsin.

Baetis ephippiatus and *Baetis quilleri* larvae were collected from submerged aquatic vegetation and wood in current varying from 0.2 m/s in silty areas to 0.4 m/s in sandy reaches. Riparian vegetation formed a partially closed canopy over the stream which varied from 3 m to 15 m in width. Common co-habitors were *Hydropsyche rossi* Flint, Voshell, and Parker, *Caenis* sp., *Stenacron floridensis* (Lewis), *Polypedilum* sp. and *Rheotanytarsus* sp. In Florida, *B. ephippiatus* occurs on vegetation in sand bottom streams (Berner, L., 1950. Univ. Fla. Biol. Sci. Ser. 4:1–267). Since *B. quillieri* larvae were only recently described no comparative ecological data exist.

Baetis longipalpus colonized bole wood, tree limbs, and whole trees in the Red River, a highly erosional environment where shifting sand is the dominate bottom type. The collection area was 250 m to 400 m wide and 4 m deep; current varied from 0.3 m/s to 0.8 m/s. Large rivers are the only known habitat of *B. longipalpus* (Morihara, D. K. and W. P. McCafferty, 1979. Proc. Entomol. Soc. Wash. 81: 34–37). Other species sharing this habitat were *Hydropsyche orris* Ross, *Pychopsyche flava* (Hagen), *Pentagenia vittigera* (Walsh), *Torotopus incertus* (Traver), *Polypedilum* sp., and *Rheotanytarsus* sp. The ephemeroids were captured from the drift; presumably they burrowed into stable clay banks.

Since *Spinadis* sp. and *Anepeorus simplex* were collected in drift nets in mid-river, their specific habitat was not observed. At the collection site, the Arkansas River is 500 m wide and 6 m deep with a boulder and gravel bottom. Current varied from 0.7 m/s to 0.9 m/s; however, wingdams greatly reduced the current near shore permitting a silty substrata to form. These species are apparently restricted to large rivers (Edmunds, G. F. Jr., S. L. Jensen, and L. Berner, 1976. Univ. Minn. Press, Minneapolis, pp. 1–330). *Cyrnellus fraternus* (Banks), *H. orris*, *Hexagenia* sp., *P. vittigera*, *Dicrotendipes* sp., and *Gyptotendipes* sp. were dominant members in this community.

Leptohyphes dolani occurred on calcareous rock and wood in slow current (0.2 m/s) in the Withlacoochee River; most of the surface was shaded by a dense tree canopy. *Baetis ephippiatus*, *Stenonema exiguum* Traver, *Hydropsyche venularis* Banks, *Chimara socia* Hagen, *Pentaneura* sp., and *Rheotanytarsus* sp. were abundant at this site. Allen (1967. Can. Entomol. 99: 350–375) reported *L. dolani* from the Savannah River in Georgia but did not describe the habitat.

I thank W. P. McCafferty and J. D. Unzicker for verification of Ephemeroptera and Trichoptera identifications, respectively.

Thomas M. Lager, *3184 W. Fairview Rd., Neenah, Wisconsin 54956.*

BOOK NOTICE

Butterflies East of the Great Plains. By Paul A. Opler and George O. Krizek. 1984. Johns Hopkins University Press, Baltimore and London. xvii, 294 p., 54 pls. Price: $49.50.

I am proud to have my name acknowledged in this excellent book, although I merely furnished the authors with a little information concerning the derivation of some of the scientific names. It is a fine compendium of knowledge of the nearly 300 species of butterflies found east of the Great Plains, including the first row of States west of the Mississippi River, and with the distribution of most of them on outline maps. Jerry A. Powell, who wrote the foreword, concisely states "What sets this book apart from its predecessors is its emphasis on biological relationships." The plates show 324 color figures of photographs of live specimens, some of which are therefore naturally not very artistic, but they do show how the insect actually appears.

The book is an excellent example of the bookmaking art; it will stand a lot of handling, is easy to read, and contains ample indexes as well as a bibliography of 285 citations. One of my lepidopterist colleagues remarked in pure Colloquial American, "I see where I'm gonna hafta lay out fifty bucks for another butterfly book."

George C. Steyskal, *Cooperating Scientist, Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, USDA, % U.S. National Museum of Natural History, NHB 168, Washington, D.C. 20560.*

ANNOUNCEMENT

The International Commission on Zoological Nomenclature publishes notices of possible use of its plenary powers in the *Bulletin of Zoological Nomenclature*. In order that the Commission have the best possible advice from zoologists, the Secretary of the Commission, R. V. Melville, asked that the Proceedings carry these notices for additional publicity. Beginning with this issue, the Proceedings will list, as they are received, the notices dealing with names of insects.

The following notices were published in *Bull. Zool. Nomencl.* 41(3) on August 23, 1984. The Commission welcomes comments and advice on these within six months or as soon as possible after the date of publication in the *Bulletin*. Send comments to: Secretary, International Commission on Zoological Nomenclature, ℅ British Museum (Nat. Hist.), London SW7 5BD, United Kingdom.

Case No. 239.—*Tibicina* Amyot, 1847 and *Lyristes* Horváth, 1926 (Insecta, Hemiptera, Homoptera): proposed conservation by the suppression of *Tibicen* Berthold, 1827. Also, Arguments pour la suppression du nom de genre *Tibicen* et de ses dérivés dans la nomenclature de la superfamille CICADOIDEA.

Case No. 2142.—*Hypocryphalus mangiferae* (Stebbing, 1914) (Insecta, Coleoptera): proposed conservation under the plenary powers.

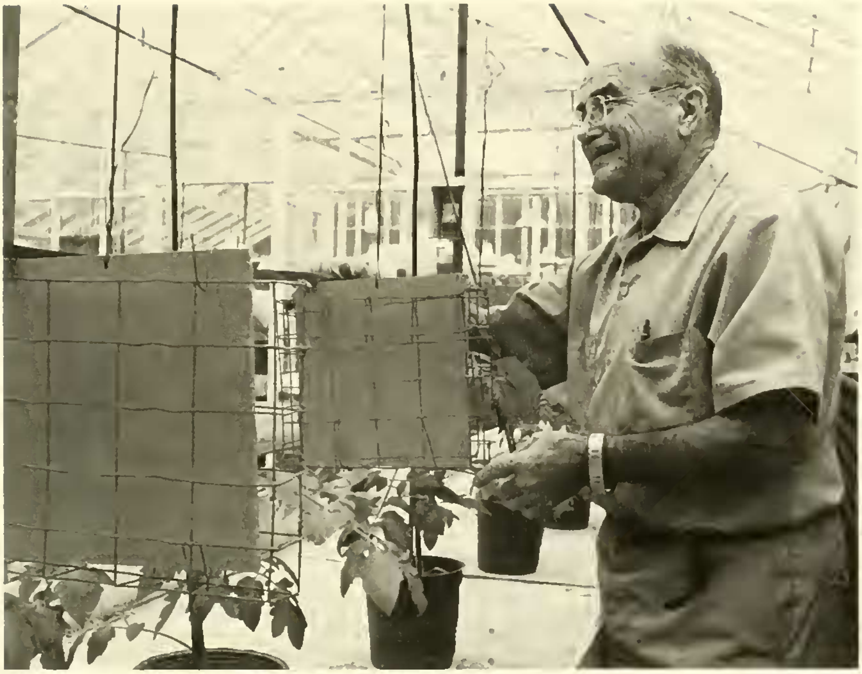
ANNOUNCEMENT

The International Commission on Zoological Nomenclature announces that the Third Edition of the International Code of Zoological Nomenclature will soon be available. The book consists of parallel English and French texts, totaling about 320 pages (216 mm × 318 mm). It will be for sale for £15, plus £1.50 for postage and handling, through the Publications Sales, British Museum (Natural History), Cromwell Road, London SW7 5BD, United Kingdom. Individuals and organizations may also purchase the book for $21.50, postage and handling included, through the American Association for Zoological Nomenclature, Room W-115, National Museum of Natural History, Washington, D.C. 20560.

A prepublication price of $18.75, postage and handling included, for individuals is in effect until March 31, 1985. Delivery of the Code will be in spring, 1985. Checks drawn on a United States bank or International Money Orders should accompany all U.S. orders. Please make checks payable to American Association for Zoological Nomenclature.

PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 259–261

OBITUARY



FLOYD FRANKLIN SMITH
1900–1984

On April 26, 1984, Floyd F. Smith died of complications following an operation. Thus ended an extraordinarily productive career in economic entomology, acarology, and virus–vector relationships that spanned 60 years. Floyd was born on July 27, 1900, on a farm in Hinckley, Ohio. He was educated in the public school system, and went on to graduate from Ohio State University in Agriculture in 1923. While still a student, Floyd worked for the USDA scouting corn borers and studying the insect vectors of the virus diseases of raspberries. This latter work was published in *Phytopathology* in 1924, the first of over 100 papers relating primarily to plant diseases and virus–vector relationships.

After receiving his MS degree from Ohio State University in 1924, Floyd was employed by the Pennsylvania Bureau of Plant Industry, Willow Grove, Pennsylvania, where he studied insects of greenhouse and nursery crops and conducted nursery inspection. This provided him with a first hand working knowledge of the pest problems faced by nurserymen and greenhouse operators that proved valuable through his entire career. He continued his studies at Ohio State during this period, completing his Ph.D. requirements in Entomology in 1929. This same year he joined the Agricultural Research Service, where he worked with F. W. Poos until 1931, studying the biology and control of leafhoppers affecting forage crops at Arlington Farm, Virginia. The most important work of Floyd's early career includes his studies on the biology and control of the black vine weevil (the subject of his Ph.D. dissertation), the work on leafhopper feeding damage that elucidated the true nature of hopperburn, and his work demonstrating the nature of the sheath material in the feeding punctures of leafhoppers. These studies are still regularly cited in the literature more than 50 years after publication.

From 1931 to 1957, Floyd worked on the biology and control of insects and mites of ornamental and greenhouse crops, first in Washington, D.C., and later at Beltsville, Maryland. He became Station Head for this group in 1953. His most important contribution during this period was the introduction in 1943 of the insecticidal aerosol for use by greenhouse ornamental and vegetable growers. This resulted in the elimination of many common greenhouse pests and greatly increased the level of control of other pests, resulting in improved crop yields and quality. Also during this period, Floyd saved the gladiolus industry from possible destruction by the gladiolus thrips, which had spread throughout the U.S. and Canada following its introduction in 1929. He discovered that the insect cannot survive out-of-doors in temperate regions but passes the winter in the corms in storage. With his development of effective treatment for the corms, the thrips were effectively controlled.

In 1957 Floyd became an administrator, as Acting Head, Truck Crop and Garden Insects Section, Fruit and Vegetable Insects Research Branch of the Entomology Research Division. Floyd detested administration and gratefully returned to active research in 1958 as Investigations Leader, Ornamental and Greenhouse Crop Insects Investigations (later renamed Vegetable and Ornamental Plant Insects Investigations), where he remained until his 'retirement' in 1970. In 1962, he was the first to report a new leafminer pest on chrysanthemum, and he worked on aspects of the biology and control of this increasingly important pest now known to be *Liriomyza trifolii* for the next 22 years. During this time he also developed the concept of insect repellency using reflective foil mulches.

After his formal retirement, Floyd remained active in research as a Collaborator with the Florist and Nursery Crops Laboratory. He collaborated in biology and control studies on the greenhouse whitefly, rose midge, willow beaked-gall midge, and the periodical cicada. Beginning in 1964, Floyd made a number of trips to El Salvador giving technical assistance to the Government of El Salvador. Working with plant pathologists such as J. P. Meiners, R. H. Lawson, H. E. Waterworth and others, Floyd spent a large part of his retirement identifying the viral problems of Central American crops. The use of sticky yellow panels to monitor or control various greenhouse pests was one of the principal projects of his last years. Floyd remained active to the very end, and was writing manuscripts and planning new studies up to the time of his death.

Besides being an entomologist and a plant pathologist, Floyd was an internationally known acarologist. Floyd's contributions to acarology are documented in some 47 papers. His early work in this area consisted primarily of studies on the biology and control of tarsonemid mites such as the cyclamen mite and the broad mite. However, his most economically significant work was with the two-spotted spider mite. Floyd was the first, in 1949, to find two-spotted spider mites resistant to organophosphate pesticides. He also pioneered the development of integrated biological/chemical methods of controlling spider mites using insecticide-tolerant strains of *Phytoseiulus* and *Typhlodromus* predator mites. In summary, he succeeded, over a 30 year span, in reducing the two-spotted spider mite from a serious threat to the greenhouse industry to a pest that is ever present but readily controlled.

Floyd was an honorary member of the Entomological Society of America, which he served as past president of the Eastern Branch, past chairman, Section C, as Representative to the National Academy of Sciences Division of Biology and Agriculture (1951–1956), and as official ESA delegate to the Eleventh International Congress of Entomology, Vienna, Austria, 1960 (where he was also the official delegate of the American Phytopathological Society). Among his many awards were the USDA Superior Service Award, the Outstanding Achievement Award (now the L. O. Howard Award) from the Eastern Branch, ESA, the William Herbert Medal from the American Plant Life Society, and the Outstanding Research Award from the Foundation for Floriculture of the Society of American Florists.

Floyd was unfailingly polite but firm of opinion. He enjoyed the company of others and attended grower or professional meetings with zest, being constantly engaged in conversation from early morning to late night. He was always busy, but never too busy to help younger scientists or to meet visitors. He was generous with praise and in giving credit to others. His vast store of knowledge, his gentle sense of humor, and his willingness to listen made him a joy to know and an ideal collaborator.

The publication list for Floyd F. Smith has been compiled and totals 337 entries, with Floyd as senior author of 140.

His wife, Dorothy K. Smith, died in 1983. He is survived by his son Dwight and his daughter Margaret, and by seven grandchildren.

Ralph E. Webb, *Florist & Nursery Crops Laboratory, Agricultural Research Service, USDA, Beltsville, Maryland 20705.*

(Remarks read at memorial service, May 12, 1984,
Beltsville Agricultural Research Center.)

PROC. ENTOMOL. SOC. WASH.
87(1), 1985, pp. 261–263

I believe—in one way or another—we all had a love affair with Floyd Franklin Smith. I first met Floyd in the late sixties when I was working as a graduate student on forage crop insects at the University of Maryland. I later joined the Agricultural Research Service in 1970 and became increasingly aware of Floyd, mostly through passing conversations, and developed an easy association in 1977 after transferring to the Florist and Nursery Crops Laboratory. It seems terribly ironic to meet a man professionally at an age when most are retired or are deceased. Floyd and I spent a lot of time together discussing the joy we found in entomology, and interestingly enough, we were never destined to publish jointly. I would like to think our association was more that of friends with common interests than of research colleagues.

Floyd was a forty-niner of sorts, a pioneer in the fields of entomology and plant pathology. Floyd's favorite expression to convey the meaning of a significant new finding was to refer to it as a nugget. Floyd's sharp mind and eyes were always on the alert for new nuggets or those overlooked by others. New findings were as important to him as the discovery of a new species by a taxonomist. These nuggets were the treasures of his life.

Floyd's attitude towards insects was simple; "Bet on the bug" he would say. Pressed on the meaning, Floyd would smile, in the way only he could, and tell of the way entomologists 40 years ago were sweating out their futures during the advent of DDT. DDT, it was said, would put many entomologists out of work. The realities of insect resistance certainly changed the concern for entomologists but it also instilled in Floyd a greater respect for insects.

Floyd loved to laugh and tell stories as well as share anecdotes. In recent years he found room in his life to laugh at events in the past which were annoyances or impediments to progress during an earlier time. We all have guidelines or internal mechanisms that we rely on to get us through the tribulations of life. Floyd had humor and laughter and he would gladly espouse the practice to others. His basic recommendation was that vigorous daily exercise of the diaphragm was essential to good mental health. Floyd had a deep hearty infectious laugh, one that would carry the distance and cause others to smile or laugh with him.

Floyd knew well the value of the dollar. He was extremely grateful to have a job with the USDA at Arlington Farms and Beltsville during the terrible depression. Salaries for scientists until recent times were only enough to get by on. There is a record of Floyd as a GS-15 during the sixties receiving $13,700 per annum. How, then, does one send a very bright young son to medical school? This is a story very few know and I think it should be told since it says so much about Floyd's unselfishness. Floyd would drive to turf farms in the evenings and on weekends to collect grubs from cut sod. At home he would inject them with milky spore disease and harvest the grubs 21 days later to be sold to a commercial producer of milky spore disease in Virginia. Floyd and Dorothy both worked on this project and it provided financial resources to help send Dwight to medical school.

One would be inclined to wonder how a very busy man in his fifties would have time to establish a wholesale nursery. The nursery served Floyd well. Floyd would have disagreements on occasion with line management. Bear Garden Nursery was a wonderful outlet to deal with frustration. Floyd once mentioned that he never let personal differences interfere with research goals. Bear Garden also provided an opportunity to perfect grafting skills which were also applied in research. Sales from Bear Garden provided an opportunity to establish a scholarship fund in entomology at Ohio State University. The only vacation Floyd ever admitted to taking from his research program was a week of annual leave in the early fifties to work with Tony Boswell to erect a shed at the nursery. Floyd's favorite conifer was the hemlock and I cannot tell you why.

Floyd always had a long list of research projects that he considered important. These were serious goals and were part of the motivating force and drive that resulted in 14 years of postretirement service to science and the government. Floyd's most recent joy was the arrival of Hiram Larew as a post-doc and now a career scientist with this agency. Floyd has always been troubled with the wealth of unknown information on the dogwood club gall which is a chronic problem in the nursery trade as well as Bear Garden. The arrival of Hiram with a devoted interest in gall insects provided Floyd with an additional incentive to finally chip away at this giant nugget.

To my knowledge there is only one student of Floyd Smith. Ralph Webb will probably share with us some day what it was like to have Floyd as one's supervisor and mentor and how he stood the heat. Floyd obviously selected Ralph as carefully as he selected his research projects and pursued both with equal vigor. We see in Ralph an accomplished scientist in his own right.

Floyd is best known for his devotion to science. His career is characterized by hundreds of publications in diverse areas of entomology and plant pathology. An anecdotal story about Floyd's graduation from Ohio State perhaps hints at his leadership and his strong independent nature. Floyd and George Langford were classmates and scheduled to graduate at the same ceremony. They decided for independent and various reasons not to attend the Saturday graduation rehearsal. It was coincidental that Floyd and George were seated in the front row next to the aisle. At the close of the ceremony, when everyone stood up, Floyd and George took this as the signal to lead the procession of students out of the auditorium and they thus departed up the aisle. It was not until they were outside and saw that they were immediately followed by the Regents, the President and faculty, did they realize what independent steps they had taken. Years later George and Floyd were both to work closely with Maryland nurserymen for several decades and George Langford is with us today.

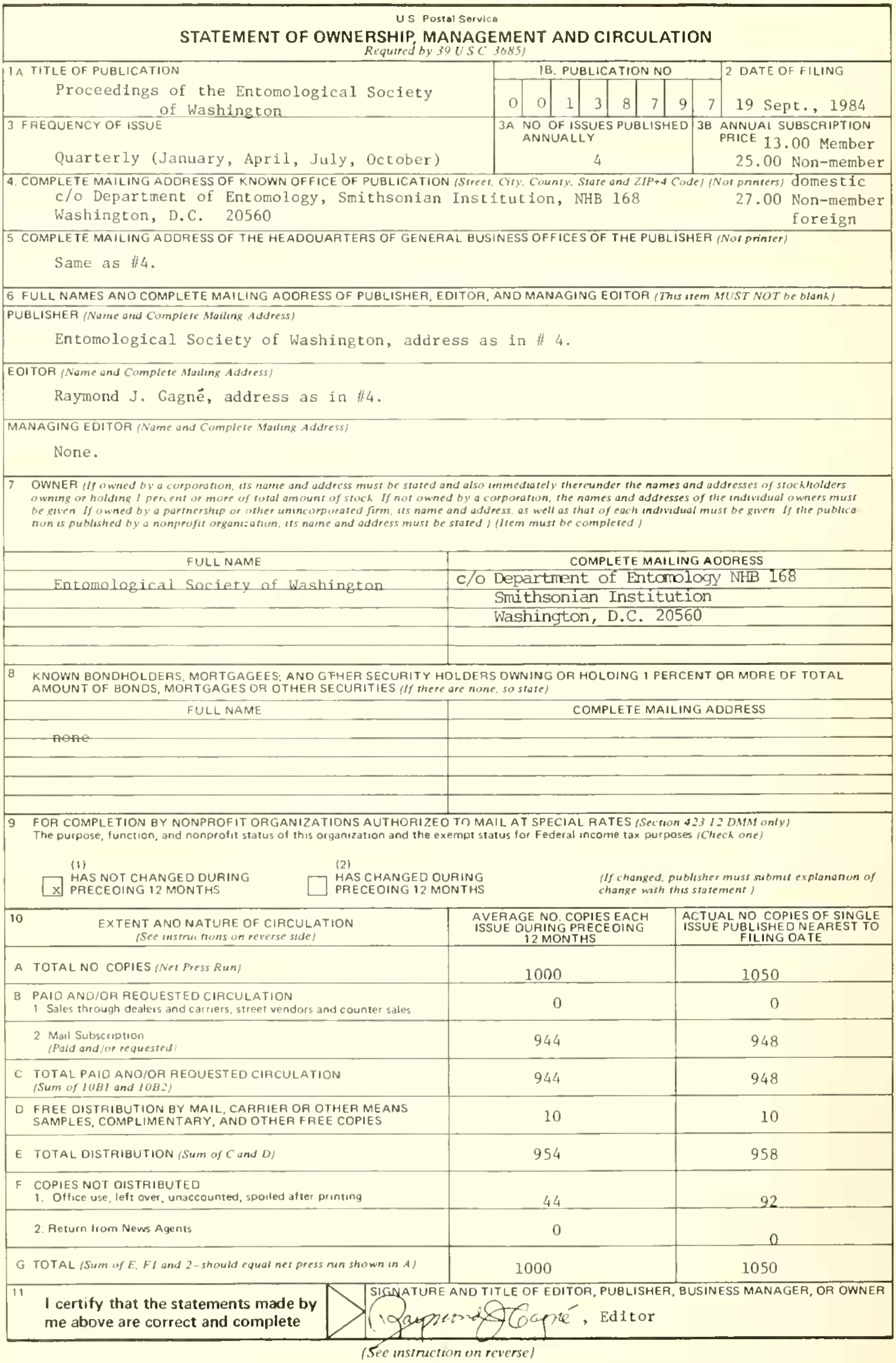
I once asked Floyd which research accomplishments throughout his career he felt the best about, that is, which were his most significant contributions. Floyd's pause was significant. He mentioned his Ph.D. work on the black vine weevil; the discovery of the true cause of hopperburn in potatoes and beans—that it was not a virus as suspected but that the condition was due to mechanical damage and plugging of vascular tissue; he also mentioned finding the first phosphate resistance in two-spotted spider mites. I asked him what, if any, they had in common. He again paused to reflect. He said that they would stand the test of time. I believe this statement would be a fitting epitaph. Floyd—as a loving father, a faithful husband to Dorothy, the quintessential scientist devoted to solving problems and as a friend—has stood the test of time.

Floyd was the first to announce spring to those who worked in Building 470—his address for almost 50 years. Everyone knew spring was at hand when Floyd would put on his battered straw hat, pick up his garden basket and pruning shears, and head off to the willow grove in late February to continue his annual love affair with the willow gall midges. Floyd would always bring pussy willow cuttings back for the secretaries.

Floyd's wealth was in the fundamental freedom to pursue research goals, to make important discoveries and to have these findings become available to the nurseryman and homeowner. Floyd was a unique civil servant; he had a social conscience. Floyd felt strongly that since his career was supported by the taxpayer, it was his obligation to solve problems of practical value.

After Dorothy died, which was a little more than a year ago, Floyd expressed his greatest concern. He said it was always a shock to him to enter a room at home where he would normally expect to see Dorothy and find only emptiness and silence. This bothered him greatly. He said he found great comfort with his friends here at the research center. I am certain Floyd would find some discomfort by what is said of him here today and in the way we hold him in such high esteem. I do hope that what passes here today is of some comfort to the family and friends of Floyd Franklin Smith.

John W. Neal, Jr., *Florist and Nursery Crops Laboratory, Agricultural Research Service, USDA, Beltsville, Maryland 20705.*



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HOST ALTERNATION: A NEWLY DISCOVERED ATTRIBUTE OF THE PHYLLOXERIDAE (HOMOPTERA: APHIDOIDEA)

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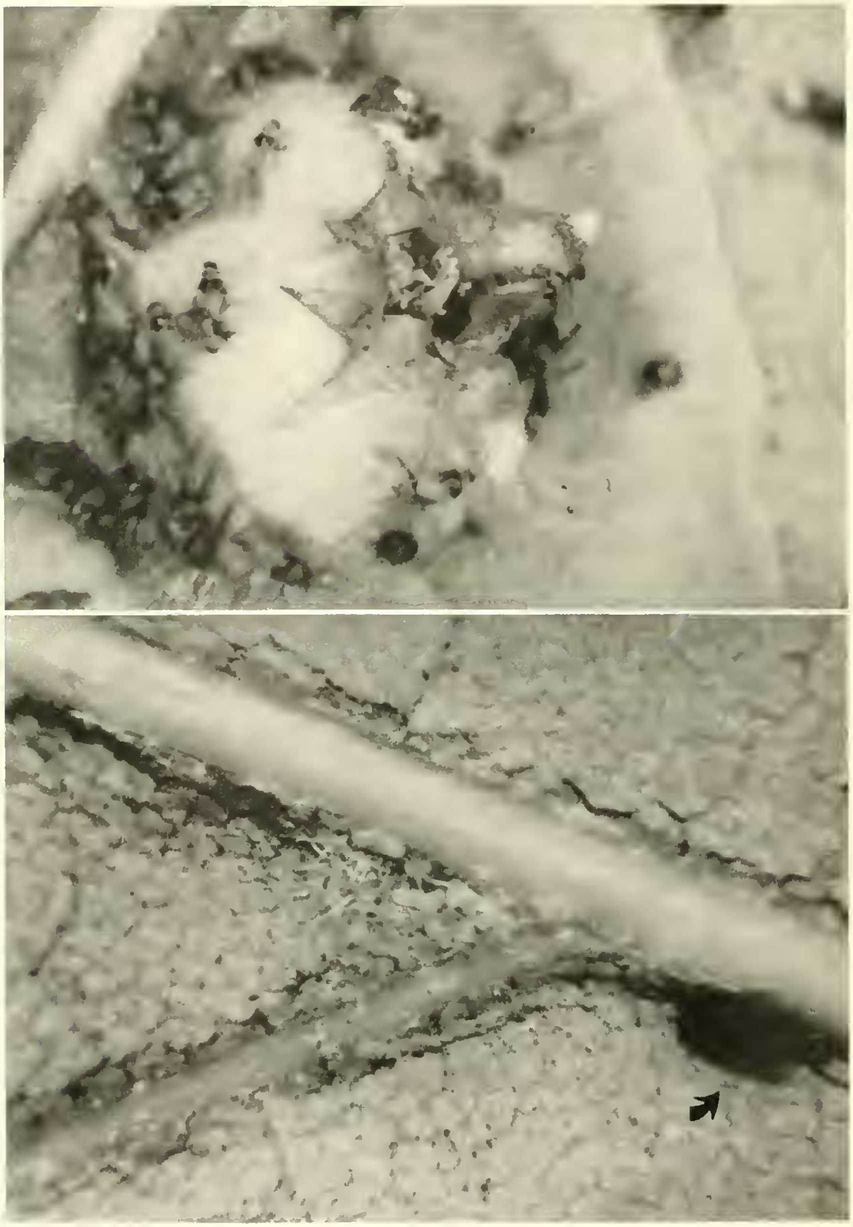
Abstract.—This is the first report of host alternation in the Phylloxeridae from one plant family (Juglandaceae) to another (Fagaceae). A six-year study of *Phylloxera* indicates that *P. texana* Stoetzel and *P. castanea* Pergande exhibit host alternation in their life cycles. In these species of *Phylloxera, Carya* (hickory) is the primary host with the secondary host being a species of *Quercus* (oak) or *Castanea* (chestnut). The Phylloxeridae, Aphididae (aphids), and Adelgidae (adelgids) constitute the superfamily Aphidoidea (Homoptera); and host alternation from one plant genus or family to another is well established in the Aphididae and Adelgidae. However, host alternation from one plant genus or family to another has not been reported or even suspected previously in the Phylloxeridae.

This paper reports for the first time the existence of host alternation in the Phylloxeridae from one plant family (Juglandaceae) to another (Fagaceae). The Phylloxeridae, Aphididae (aphids), and Adelgidae (adelgids) constitute the superfamily Aphidoidea (Homoptera); and host alternation from one plant genus or family to another is well established in the Aphididae and Adelgidae. Eastop (1966) reported that in Europe *Phylloxera florentina* Targioni-Tozzetti alternates between *Quercus ilex* and *Q. robur*, but host alternation from one plant genus or family to another has not been reported or even suspected previously in the Phylloxeridae.

From 1978 to 1984, I conducted a detailed study of the biology and morphology of species of *Phylloxera* on *Carya illinoiensis* (Wang.) K. Koch. (pecan) in Georgia, Louisiana, Oklahoma, and Texas (Stoetzel, 1981). During the study, I followed the development of the life stages from overwintering egg to overwintering egg for three gall-producing species that spend their entire life cycles on pecan in the United States; namely, *Phylloxera devastatrix* Pergande, *Phylloxera notabilis* Pergande, and *Phylloxera russellae* Stoetzel. I also observed a fourth species, *Phylloxera texana* Stoetzel, which exhibited a different developmental cycle.

In the spring, *P. texana* produced galls on pecan leaves; alate females escaped from the galls (Fig. 1), but further development on pecan was not observed, and overwintering eggs were never found. In an attempt to collect eggs, several hundred alate females of *P. texana* were collected from leaf galls and were isolated in small dishes. Only rarely did a female lay an egg, and no eggs hatched. Currently, *P. texana* is known only from the Texas counties of Brazos, Brown, and Menard.

In mid-May 1982 I studied populations of *P. texana* on pecan in Texas. When I isolated alate females from leaf galls in dishes with moistened filter paper or



Figs. 1–2. 1 (top), Alate females of *Phylloxera texana* escaping from gall on pecan leaf. 2 (bottom), Alate female of *Phyloloxera texana,* at arrow, with eggs and first instar nymphs in the tufts of hairs at the intersection of a secondary vein with the midvein on the lower surface of an oak leaf.

with newly formed pecan leaves or with pecan stems, the females died without laying eggs. When I put alate females from leaf galls in containers with leaves from *Quercus falcata* Michx. or *Q. virginiana* Mill., they readily laid many eggs that hatched into feeding first instar nymphs. An intensive check of the leaves of oak trees in the vicinity of the pecan trees resulted in the collection of alate females of *P. texana* laying eggs in the tufts of hairs at the intersections of the secondary veins with the midvein on the lower surface of the oak leaves (Fig. 2). By late May immature stages and a few adult apterous females were found on oak leaves. Development continued on oak with the production of both alate and apterous females were found on oak leaves. Development continued on oak with the production of both alate and apterous females in June. Based on my experience with and knowledge of the developmental cycles of other species of *Phylloxera*, I predict that alate females of *P. texana* return to pecan in the fall and lay eggs that develop into sexual males and females (oviparae), and that, after mating, a sexual female will produce one overwintering egg. My attempts to establish greenhouse colonies of *P. texana* have been unsuccessful; and, since I have not been in Texas during the months of September and October, I have been unable to observe field populations in the fall.

From 1979 to 1984, I studied species of *Phylloxera* on chestnut (*Castanea dentata* (Marsh.) Borkh., *C. mollissima* Blume) and oak (*Quercus alba* L., *Q. palustris* Muenchh.) samples sent to me from West Virginia. From January to June of 1980, I was not able to find overwintering eggs on samples of twigs or branches of either chestnut or oak. The first phylloxerans I observed in samples from these trees were found in early June on the leaves, and they were alate females laying eggs that hatched into feeding first instar nymphs. Several overlapping generations of alate and apterous females were produced throughout the summer months and into September and October when the leaves began to senesce and fall from the trees. No males or overwintering eggs were collected from chestnut or oak; and only one oviparous female was collected, in October 1980, from chestnut. In June 1981 I spent a week in Frametown, West Virginia, looking for overwintering eggs and early developmental forms of phylloxerans on chestnut trees. The first life stage encountered on chestnut leaves were alate females which laid many eggs that hatched into feeding first instar nymphs. During this same period, I collected galls of an undescribed *Phylloxera* from three hickory trees, *Carya tomentosa* (Poir.) Nutt., bordering one of the nurseries containing the chestnut seedlings; and I discovered that the alate females escaping from galls on the hickory trees appeared to be identical, morphologically, with the alate females I was collecting from chestnut leaves. In late September 1981 I again spent a week in West Virginia working in the same chestnut nurseries. I found no sexual forms on the chestnut trees, but I did find solitary alate females laying eggs that were producing sexual males and females on the hickory trees. Overwintering eggs were also found on these hickory trees.

In March 1982, 1–2 year old bare-rooted seedlings of *Carya glabra*, *C. tomentosa*, *Castanea dentata*, *C. mollissima*, *Quercus alba*, and *Q. palustris* were fumigated, planted, and held in a greenhouse for transfer work. In June 1982, pots containing these six plants plus *Rosa* 'Forever Yours' were isolated in 6 cages with 32 × 32 mesh screen. I received samples of leaf galls from one of the *Carya tomentosa* bordering the chestnut nursery near Frametown, West Virginia; and I put these samples into 4 of the 6 cages with the test trees. Additionally, leaf galls were put into a small, isolated greenhouse far removed from the other plants and in which I had put two *Quercus alba*, two *Q. palustris*, four *Castanea dentata*, and four *C. mollissima*. By July it was clearly evident that no phylloxerans were on the *Carya*, *Quercus*, or *Rosa* plants in any of the six cages or in the isolated greenhouse. However, large populations of phylloxerans had developed and were causing discoloration along the veins of the leaves on the chestnuts in the four cages and on all of the leaves of the chestnuts in the isolated greenhouse into which leaf galls from the hickory tree had been placed. None of the chestnut plants outside the cages in the large greenhouse had any phylloxerans on them. In September 1982, I tried to transfer alate females from *Castanea* back to *Carya*, but the transfers were unsuccessful. I conclude that the hickories, for one reason or another, were not acceptable to the phylloxerans. Hickory trees are slow bearing, and I have been unable to obtain nuts from the trees in West Virginia. During 1983 I did not find even one phylloxeran on the 8 chestnut plants in the isolated greenhouse or on the 8 caged chestnut plants in the large greenhouse. The plants survived over winter, leafed out in the spring, and continued to do well throughout 1983 and again in 1984. The phylloxeran population had been very heavy on all of these chestnuts during 1982; and, if sexual males and females and overwintering eggs had been produced, there should have been enough produced to have carried the population into 1983.

This six-year study of *Phylloxera* populations indicates that *P. texana* and *P. castanea* exhibit host alternation. I maintain that in these species of *Phylloxera*, *Carya* (hickory) is the primary host with the secondary host being a species of *Quercus* (oak) or *Castanea* (chestnut).

In North America, only *Phylloxera castanea* has been reported from *Castanea*, eight species of *Phylloxera* have been reported from *Quercus*, and approximately 50 species of *Phylloxera* have been reported from *Carya* (Haldeman, 1850; Riley, 1874; Pergande, 1904; Ferris, 1919; Duncan, 1922). Only by doing host transfers from *Carya* to *Quercus* and/or *Castanea* and back to *Carya* will it be possible to show relationships of species and to determine which specific names are valid.

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A NEW NEARCTIC SPECIES OF *PHROSINELLA* (DIPTERA: SARCOPHAGIDAE)

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Abstract.—*Phrosinella* ***aurifacies***, n. sp., is described from the Nearctic Region. It is the most common species of the genus in eastern North America but was overlooked because it has been confused with *Phrosinella fulvicornis* Allen. The male genitalia are very uniform and not useful for distinguishing species in this group. Apparently ***aurifacies*** is isolated from sympatric relatives primarily by means of the females' recognition of the male facial pattern rather than by anatomical incompatibilities in the male genitalia.

A previously unrecognized *Phrosinella* is described below to make the name available for the paper by Margery Spofford and Frank Kurczewski, which follows. It is a typical miltogrammine fly (Miltogramminae, Miltogrammini). The morphological terminology is that of the "Manual of Nearctic Diptera, Vol. 1" (McAlpine et al., 1981). The means with standard deviations are each derived from measurements of 13 specimens.

This species exhibits all the principal characters of *Phrosinella* as redefined in a forthcoming revision of the Nearctic Miltogramminae: some whitish hairs present on posterior surface of head below neck; frontal vitta broad, about 4 times as wide as frontoorbital plate halfway from median ocellus to lunule; 2 proclinate and 1 reclinate frontoorbitals; lunule setulate and pollinose; parafacial with scattered minute setulae only; facial ridge without large bristles above vibrissae; vibrissae differentiated and at level of ventral edge of facial plate; third antennal segment 3 or more times length of second; hinge plate rudimentary; palpus orange; prementum short, bulbous and pollinose. Distal section of CuA_1 (beyond crossvein dm-cu) less than half length of basal section; distal half of fore tibia with a loose ventral comb or brush of amber bristles in a longitudinal row (both sexes).

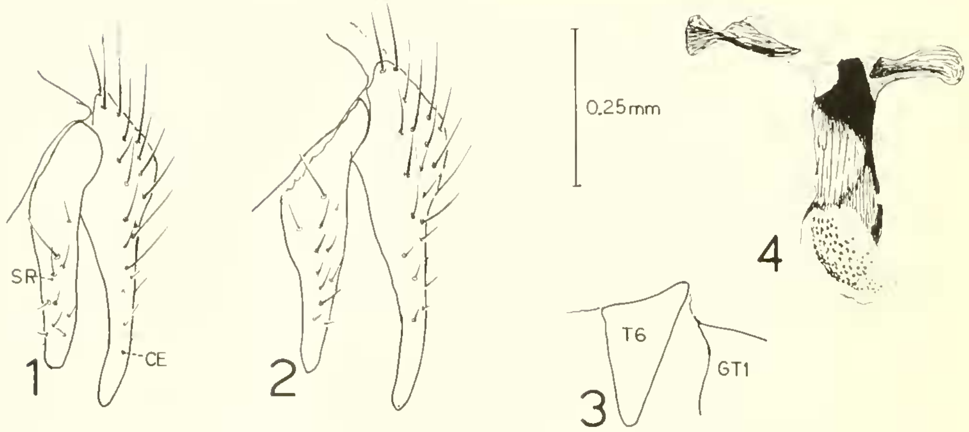
Phrosinella aurifacies, New Species

Figs. 1–4

Size.—3.5 to 7.0 mm.

Male.—Frontal vitta, frontoorbital, facial and parafacial plates golden pollinose (vitta sometimes paler to light tan on middle); front at level of anterior ocellus 0.425 ± .012 of head width (holotype, 0.41), at narrowest near antennal base, 0.367 ± .014 (holotype, 0.37); antenna bright orange; arista thickened 0.518 ± .027 of length (holotype, 0.54).

Dorsum of thorax with acrostichal area to most of upper surface tan to brown or somewhat bronze pollinose; lateral edges of scutellum dark tan to brown pol-



Figs. 1–4. 1, *Phrosinella aurifacies*, cercus (CE) and surstylus (SR), lat. view. 2, *Phrosinella fulvicornis*, cercus and surstylus, lat. view. 3, Lateral profile of sixth tergum (T6) and anterior portion of syntergosternum 7 + 8 (GT1) of *Phrosinella fulvicornis*. 4, *Phrosinella aurifacies*, aedeagus (lat. view) with attached duct and pump sclerite. All figures are at same scale; the parts are drawn as if genitalia were spread with the tips of cerci, surstyli, and aedeagus pointing ventrally, and with the fly facing left.

linose (rarely pale); acrostichals, 0:1; dorsocentrals, 2:3; intraalars, 1:1; supraalars, 1:2 (the posteriormost of the usual set of 3 absent or weak); dorsal katepisternals, 2.

Foretibia without or with a very weakly differentiated posterior bristle; foretarsus modified, 2nd segment short, with a loose ventral and somewhat posterior tuft of fine long hairs extending beyond tip of fourth tarsomere; tarsomeres 3 to 5 atrophied (fig. 16, of Allen, 1926); legs black in ground color.

Wing with a faint but distinct clear brownish tinge on middle anterior part of wing (mainly along veins bordering cells sc, r1, r2, r4, br, and dm), rarely absent (?teneral specimens).

Abdominal terga 2 to 4 with 3 rows of blackish spots, lateral spots sometimes faint and those of tergum 4 sometimes confluent at posterior margin.

All sclerotized postabdominal parts blackish, surstyli somewhat paler; sixth tergum usually without setae, occasionally a bristle or two present; sixth tergum at middorsal, posterior edge produced dorsally into a small, distinctive quarter-spherical bump (Fig. 3), separated from syntergosternite 7 + 8 by a considerable length of membrane; surstylus, in lateral view, only slightly tapering from base to tip (Fig. 4); aedeagus of the basic miltogrammine type, without any conspicuously distinctive features (Fig. 4); epiphallus well-developed; pump sclerite unusually small (Fig. 4).

Female.—As male, except frontal vitta and adjacent frontoorbital tan to brown or bronze pollinose; facial plate usually golden pollinose, sometimes very faintly so; parafacial and anterior frontoorbital plates silver-white pollinose; front at level of median ocellus 0.452 ± .012 of head width, at base of antennae 0.450 ± .011; antennae usually orange, 3rd segment sometimes infuscated but not completely black beyond junction area with second segment; arista thickened 0.489 ± .031 of length.

Foretarsomeres dorsoventrally flattened, ventral surfaces of tarsomeres 2–5 covered with very fine, yellowish hairs. Wings not or but very faintly brown-tinged (in same areas as male).

Holotype:—♂, Shiawasee Co., Mich., Rose Lake Conserv. Area, June 11, 1982, Wm. L. Downes Jr., in the U.S. National Museum of Natural History, Washington, D.C.

Paratypes.—187 ♂ & 252 ♀ from the following states and Canadian provinces: Connecticut, Illinois, Iowa, Kansas, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Jersey, New York, Ohio, Pennsylvania, South Carolina, South Dakota, Alberta, Manitoba, New Brunswick, Ontario, and Quebec. A list of paratypes with collection label data is available from the author upon request. Paratypes will be distributed with copies of the collection data list to lenders and to various other institutions after this paper has been published.

The surstylus of males of the closely related *P. fulvicornis* (Fig. 2) taper more obviously in lateral view than the surstylus of *aurifacies* (Fig. 1), but the male genitalia are somewhat variable, and this difference may not hold for all specimens.

The general brown tint of the body of *aurifacies* seems to represent cryptic coloration that enables them to blend in better with the bare, brown sand on which they are usually encountered.

P. aurifacies is the most common and widespread eastern North American species of *Phrosinella*. Apparently, two more or less peripheral populations have differentiated as distinct species from it. One of these is the 'true' *P. fulvicornis* (Coquillett), with which *aurifacies* has previously been confused. *Phrosionella fulvicornis* (in agreement with the holotype in the U.S. National Museum) is conspicuously silver-white in contrast to the tan-brown of *aurifacies*, and the males lack the bright golden head pollen of *aurifacies*. *Phrosinella fumosa* Allen is the second splinter species; it differs from *aurifacies* in having a blackish third antennal segment and prominent wing spots in the male.

Both *fumosa* and *fulvicornis* have much more restricted distributions than *aurifacies*. *Phrosinella fulvicornis* has been collected along the eastern North American seaboard, the eastern shore of Lake Michigan, and in the Medora Sand Dunes in Kansas. *Phrosinella fumosa* is not commonly collected. It has been found in Delaware, Maryland, Virginia, and Michigan.

Both species are also sympatric with *aurifacies*. I have taken *fumosa* in the same sand pit and at the same time with *aurifacies* near Lansing, Michigan. I have also collected *fulvicornis* simultaneously with *aurifacies* a short distance from the seacoast near New Haven, Connecticut and near the shore of Lake Michigan in Berrien Co., Michigan.

Where they occur together (and in eastern United States in general), the males of the three species are readily distinguished, even by naked eye in the field. *Phrosinella fumosa* males have black antennae and wing spots; *aurifacies* males have a golden, and *fulvicornis*, a silver-white face and parafacialium. The wing of male *fulvicornis* lacks the faint brown tinge of *aurifacies*, but occasional *aurifacies* males (which may be teneral) also lack the brown tinge.

The females are less distinct. The usually white frontal vitta of *fulvicornis* females sometimes has a diffuse tan to brown spot on its central region, and the corresponding region in *aurifacies* is sometimes quite pale. However, the color, even when pale, usually spreads well beyond the vitta onto the frontoorbital plate in *aurifacies*, but not in *fulvicornis*. The arista is thickened to a greater extent in *fulvicornis* (0.6 of its length or a little more in both sexes), but there is a little overlap in this measurement. Some eastern females of *aurifacies* have infuscated antennae, but none from that area have antennae as black as those of *fumosa*.

Certain peripheral populations are not as easily classified. Two females from Sioux City, Iowa have very black third antennal segments, and are not included in the paratype series. The males of an excellent series from Prince Edward Island in the Canadian National Collection have quite pale pollen on their heads; it is conceivable that the series is actually *fulvicornis*. These too have been omitted from the paratype series, since their status is not clear.

In a short series of specimens from Nebraska the aristae are thickened to a greater extent than in typical *aurifacies*, and the male 'face' is only pale golden pollinose. While they are thus somewhat intermediate between *fulvicornis* and *aurifacies*, they fit *aurifacies* best, and have been assigned there. In making this judgment, I have assumed that *aurifacies* followed the Missouri River westward; it didn't differentiate there because sibling species weren't present to effect the character displacements found in the sympatric populations elsewhere.

While the male genitalia have been given special prominence in species discriminations in the Sarcophagidae, they are of little practical use in *Phrosinella*. In this respect *aurifacies* and its relatives are remarkably like the picture-winged drosophiloids of Hawaii (Kaneshiro, 1952): the males have conspicuous external differences, the male genitalia are very uniform, and the species have a courtship (see the following paper by Spofford & Kurczewski). *Phrosinella* fumosa even has pictured wings! This contrasts strikingly with many Sarcophaginae or *Eumacronychia* (Miltogrammini) in which the flies are externally very uniform but have very distinctive genitalia—just as in the scaptomyzoid drosophilids!

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COURTSHIP AND MATING BEHAVIOR OF *PHROSINELLA AURIFACIES* DOWNES (DIPTERA: SARCOPHAGIDAE: MILTOGRAMMINAE)

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Abstract.—The behavior of males and females of *Phrosinella aurifacies* Downes leading to courtship and mating is described and sequenced chronologically. Both sexes leave the surrounding vegetation in the morning and congregate near aphid colonies to obtain honeydew. Male-male confrontations include facing-off, sidling clockwise or counterclockwise, back-mounting and crawling-over, and trailing and chasing (often involving many males in tandem) flights. Male-male interactions intensify as the females become more abundant. Male-female interactions include facing-off, male wing scissoring; ovipositor rubbing/licking, back-mounting, and trailing, "yo-yo" and "roller coaster" flights. The behavior resulting from the male-male contacts may serve to decrease aggression and space the males, whereas that between male and female is invariably oriented toward copulation and insemination.

The genus *Phrosinella* contains six described Nearctic species: *aldrichi* Allen, *fulvicornis* (Coquillett), *fumosa* Allen, *pilosifrons* Allen, *talpina* Reinhard and *aurifacies* Downes in America north of Mexico (Downes, in Stone et al., 1965; Downes, 1985). *P. aurifacies* is a common eastern species which has been confused with *P. fulvicornis* until recently. The bright golden pollen of the facial and frontal areas and the bright orange antennae distinguish the males of *P. aurifacies* from all other congeners. The females usually differ from those of other species in having a tan to bronze pollinose frontal vitta with the color usually spreading well out onto the frontoorbital plate. The females of *P. aurifacies* are not always separable from those of *P. fulvicornis* (Downes, 1985).

Little is known of the ethology of *Phrosinella* spp. The adults occur on sandy or gravelly soils with sparse vegetation. Females are usually seen flying near the ground in an irregular, gyrating pattern that appears to be a search flight. They are able to find closed wasp nest entrances, at which they dig and larviposit. They may also enter "wasp-sized" holes (Allen, 1926; Evans, 1970; Peckham, 1977). Nothing has been reported of the male activity and mating behavior of members of this genus (Downes, 1983, pers. comm.).

ECOLOGY

Adults of *P. aurifacies* have several generations per year in upstate New York, based upon our rearings. They occur from mid-May through mid-October. We observed this species at three sites near Auburn, Cayuga County, and one near Chittenango, Madison County, during 1982 and 1983. The four sites, each comprised of sand or fine gravel with sparse herbaceous vegetation, were surrounded by either cottonwoods, locusts, or willows (Auburn), or, a hardwood swamp and a red pine plantation (Chittenango).

Males left the surrounding fields in early morning to congregate in open areas beneath white sweet clover (*Melilotus alba* Desr.) and cottonwood (*Populus deltoides* Marsh.). During late May and early June 1982, rainy periods dampened male activity and delayed female emergence. On sunny days the males were active from 0830 to 1840 h, and the females from 1000 to 1630 h (EDT). Both sexes reduced their activities during midday (1200–1400 h) when sand surface temperatures exceeded 45°C. Although sand surface temperatures varied from 26° to 62°C, most fly activity occurred between 35° and 40°C. In 1983 when sand temperatures in the sun reached 61°C, flies moved to the shade of the cottonwoods where surface temperatures were only 41°C. As the temperature increased, fly activity on vegetation intensified. With decreased sunlight and temperature, the flies moved back to the sand surface.

BEHAVIOR

Male interactions (Fig. 1).—*Male emergence:* The first males emerged on 17 May 1982 and 25 May 1983. They alternated resting motionless with searching for honeydew on the sand and low vegetation. While searching on the ground, the flies walked circuitously and sinuously. On vegetation, the males searched the leaf circumference and walked up and down the stems, repeatedly licking the substrate with their mouthparts. Recently emerged males spent much time on vegetation near aphid colonies.

Sand grain manipulation: Shortly after emerging and inspecting plants nearby, the males walked down from the vegetation to the ground beneath the aphid colonies and began to manipulate sand grains, interspersed with circuitous searching on the sand surface. A searching male extended his mouthparts to the sand grain, lifted it between his foretarsi and labella, and rolled it between the brushes on his foretarsi by alternately rubbing each leg forward over the grain. He then dropped the grain and stroked his mouthparts with his foretarsal brushes 2–3 times. This process was repeated 3–8 times within a 4 cm^2 area. A male then flew 5–10 cm away and repeated this manipulation. One male was seen manipulating a dead aphid that lay on the sand under the colony. Older males alternated sand grain manipulation with flights onto low vegetation.

Male-male encounters: During the sand grain manipulations and searching behavior, encounters between conspecific males were commonplace, resulting in bilateral tolerance, sidling or circling, face-offs, back-mounting and crawling over, trailing and/or chasing flights. Recently emerged males allowed one another to remain nearby for many minutes. Further intermale meetings led to rotating together on the ground by both males within a 4–10 cm^2 area. The males aligned themselves laterally, head to tail, and sidestepped clockwise or counterclockwise for 3–10 sec. Sometimes one male circled a motionless second male. Such maneuvers might then give way to any of the other above-mentioned behaviors.

As the males became more aggregatory, they approached one another and then

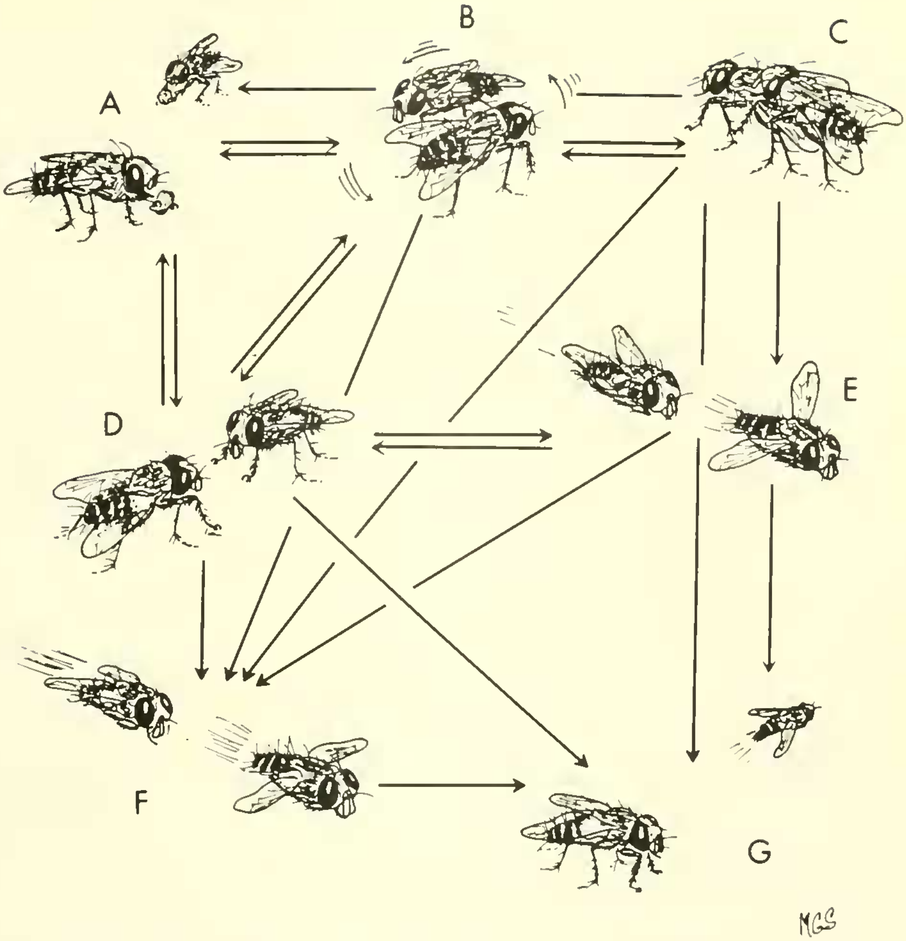

Fig. 1. Male-male encounters. A, Sand grain/vegetation manipulation (honeydew feeding). B, Sidle: two individuals walk clockwise or counterclockwise about a fixed spot. C, Back-mount/crawl-over. D, Face-off. E, Trailing flight: two or more males fly in tandem. F, Chasing flight: one male rapidly chases another. G, Separation of two males.

stood motionless face-to-face for 2–5 sec. Such face-offs may serve in sexual recognition because males had brilliant golden pollinose fronses, in contrast with tan to bronze fronses of females. Male face-offs culminated in either tolerance, feeding, back-mounting and crawling over or trailing/chasing flights. Back-mounts/crawl-overs invariably involved larger males approaching motionless smaller males from the rear, mounting them and either remaining there for 1–2 sec, or crawling over and dismounting at the opposite end.

Older males became increasingly less tolerant and chased one another in flight. This decrease in tolerance coincided with the emergence and increase in the number of females. Individual flights of males lasted 1–5 sec, attained heights of 10–30 cm for distances of 15–200 cm, and were repeated 3–16 times for a total flight time of 10–90 sec. As the fly population increased, these flights involved

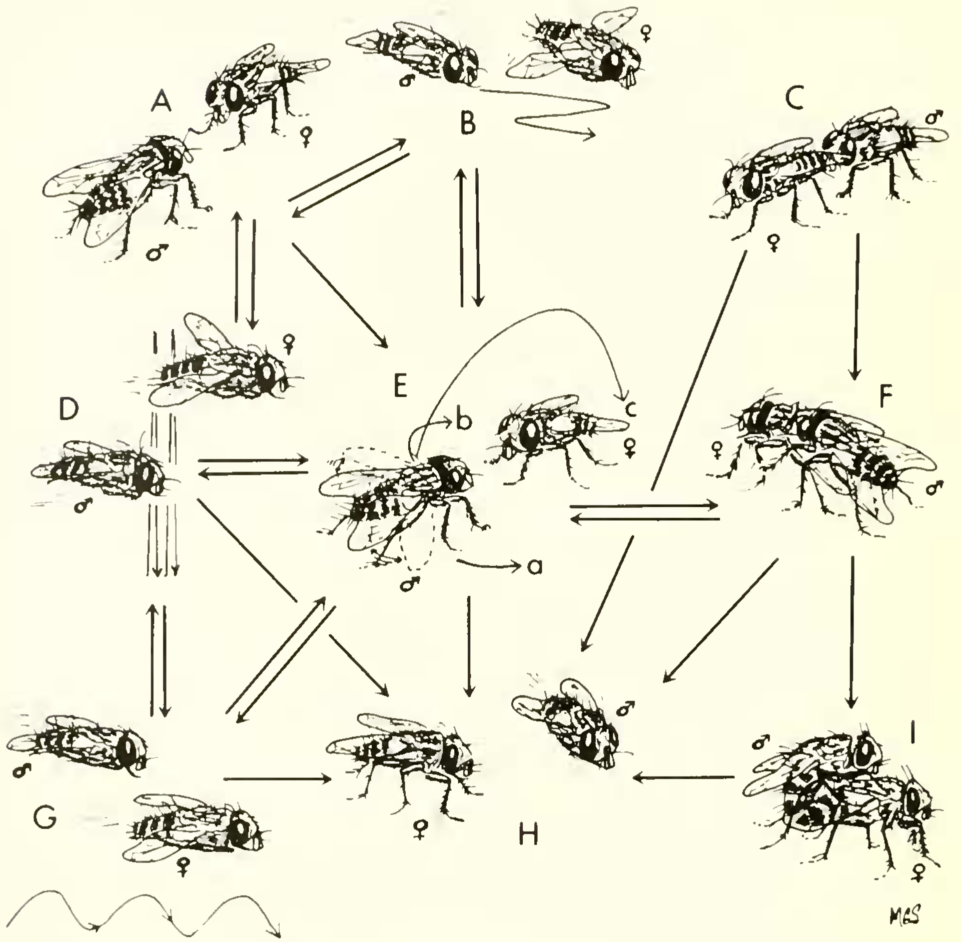

Fig. 2. Male-female encounters. A, Face-off. B, Trailing flight: male often makes zigzag flight beneath female. C, Ovipositor licking. D, Yo-yo flight: male always remains slightly below female as they both fly vertically up- and downward. E, Wing-scissoring: male scissors wings horizontally at any or all orientations (a, b, c). F, Back-mount. G, Roller coaster flight: male trails female, below her on upward portion and above her on downward portion of flight. H, Separation. I, Copulation.

as many as five males in tandem. Such flights often terminated when one or more males flew through vegetation. Some intermale encounters resulted immediately in chasing flights.

Male-female interactions (Fig. 2).—*Female emergence:* The first females of *P. aurifacies* emerged on 21 May 1982 and 6 June 1983. They walked circuitously, flew short distances, lowered their heads and paused motionless on the sand. Females focused their activities near low vegetation (*Melilotus alba, Taraxacum* sp., *Fragaria* sp.).

Male-female interactions involved elaborate courtship displays observed 95 times when sand surface temperatures were 26° to 49.5° ($\bar{x}$ = 37°) C. The bisexual displays progressed from wing-scissoring (Spieth, 1974) through trailing flights, finally, to so-called "yo-yo" and/or "roller coaster" flights.

Wing-scissoring: As a male approached a female from the front the pair paused motionless on the sand in a face-off. The male then oriented his body 45°–60° from a face-to-face alignment with hers while rapidly scissoring both wings simultaneously and horizontally for 2–5 s. During wing-scissoring a male's body sometimes waggled vigorously. A male then flew to the opposite side of a female and wing-scissored. Such bouts were repeated 3–8 ($\bar{x} = 5$) times in rapid succession, after which a male flew over and landed facing the posterior end of a female's abdomen. He either recommenced wing-scissoring, or, walked toward her and rubbed his antennae and licked with his mouthparts on her terminal abdominal segment (ovipositor?) for 1–3 ($\bar{x} = 2$) s, flew over her, landed face-to-face and repeated this sequence 1–3 times within 5–120 ($\bar{x} = 10$) s.

Some males, rather than flying over the female, sidled posteriorly across the sand, always facing her, in order to approach her from the rear. Such a male then walked toward the female and rubbed his antennae on her terminal abdominal segment. He then backed away, flew over her, landed and faced her, and recommenced his wing-scissoring.

Trailing flights: The sequence of wing-scissoring displays exhibited by a male induced a female to fly 50–250 ($\bar{x} = 75$) cm to another bare sand area, trailed 3–10 ($\bar{x} = 5$) cm by a male. Flights (N = 42) varied from 5–60 ($\bar{x} = 20$) cm in height and took 1–5 ($\bar{x} = 3.5$) s. Wing-scissoring by a male recommenced and the entire sequence was repeated.

"Yo-yo" flights: "Yo-yo" flights were elaborations of the trailing flights with a male trailing a female. Pairs (N = 36) rose repeatedly 10–40 ($\bar{x} = 25$) cm above the surface and returned to the ground from 2–9 ($\bar{x} = 4$) times in 1–6 ($\bar{x} = 2$) s, interspersed with motionless pauses of 4–20 ($\bar{x} = 6$) s or wing-scissoring. A high-pitched buzz was emitted during these and the following type of flight, but it was not ascertained which of the pair, if not both, produced the sound. Longer pauses between "yo-yo" flights occurred early in the morning (0835–0920 h) during cooler temperatures. Often, as a pair flew downward to within 5 cm of the ground, a male flew zigzag beneath a female, as though attempting to make contact with her.

"Roller coaster" flights: "Roller coaster" flights, too, were elaborations of the trailing flights, occurring usually as the sand temperatures increased. A male and female undulated in flights that ranged from 10–50 ($\bar{x} = 30$) cm above the substrate for 2–4 ($\bar{x} = 3.5$) min without landing. Sometimes during the flight the female assumed a stationary hover, 25–35 cm above the sand, for 4–7 ($\bar{x} = 6$) s, whereupon the trailing male flitted from side-to-side at 0.5–1 s intervals at a position 2–3 cm behind her. Such flights were terminated by a female landing first on the sand or leaves/twigs of nearby vegetation. A male followed and immediately commenced wing-scissoring. If he lost sight of the female when she resumed her flight, he returned to the last wing-scissoring station. The female then sallied past the male, which flew upward and followed in another "roller coaster" flight.

Many of these courtship displays terminated with either a female flying through vegetation and thereby eluding a male, the pair landing well separated, or, with the interference activities of other males. Rarely, a male lost interest in a female and flew away without any obvious external interference.

Copulation: Four copulations (1982: May 26, 1530 h, 41°C; June 9, 1650 h, 44°C; and 1983: June 16, 1420 and 1425 h, 41°C) began with antennal/mouthparts-ovipositor(?) rubbing/licking, wing-scissoring, and "yo-yo"/"roller coaster" flights. Three others (1982: June 8, 1000 h, 28°C; June 10, 1020 h, 32°C; June 18, 1004 h, 29°–30°C) were observed in progress. After the "yo-yo" or "roller coaster" flights over bare sand some females flew to moderately vegetated sand, followed by a male. The male proceeded to wing-scissor vigorously, sidle to the rear of the motionless female, climb atop her and bend his abdomen under hers. Two such copulations lasted 3 and 5 min, with individual couplings of 5–90 ($\bar{x} = 47.5$) s. Once coupled a pair made slow, ca. 30-cm-long, flights interspersed with 5–10 s pauses, over bare sand 1–4 m away.

One pair of *P. aurifacies* on damp, shaded sand was disturbed during copulation. The male struggled for 10 s to escape the genital hold of the female, which remained motionless on the substrate during all of the male's thrashings and twistings. The male eventually flew away, after which the female continued her motionless stance. She was collected in a plastic film canister, but when the canister was opened inside of an insect net, the female made no attempt to fly upward. She was dumped into the net whereupon she remained motionless. Placed in a vial, 10 min after copulation, she still had not resumed activity, appearing to be in a state of catalepsy.

On June 18, 1982 on damp bare sand, one male mounted a female and held his body at nearly a 45° angle to her dorsum with his abdomen distinctly curved under hers. The pair remained in this position for several min during which the male held the female's wings inward and almost parallel to each other with his mid- and, sometimes, forelegs. The male's wings were held backward in a "V" position. Sometimes his forelegs rested on the dorsum of her pro- or mesothorax or atop her wings. His hindlegs grasped the substrate. All of the female's legs were on the substrate, except when she used her fore- and hindlegs for cleaning.

Eight times, at intervals of 2–8 min, the male stroked the sides of the female's wings and body with his fore- and/or midlegs, usually rubbing one side at a time. The female responded by moving her hindlegs over the edges of her wings and then rubbing the underside of her abdomen with them. Then she cleaned her face, including eyes, by moving her head in clockwise and counterclockwise directions while brushing with her forelegs. She then cleaned her mouthparts with the forelegs. The male readjusted his mount on the female four times and rhythmically moved his abdominal segments.

The pair made three flights *in copulo* that were 10, 100 and 300 cm long. Each time the pair landed on an elevated ridge and, prior to take-off and after landing, the pair assumed a horizontal rather than angular posture with the male atop the female.

After 26 min of coupling, the female kicked her hindlegs alternately for 30 s, seemingly pushing upward on the underside of the male's abdomen. The male responded by cleaning his face and mouthparts with his forelegs, then lowered himself to the horizontal position. The male disengaged, dismounted and cleaned his head and mouthparts with his forelegs. The female cleaned her head and wings, then flew a few centimeters away. She made three several centimeter-long flights, pursued by the male. The male and female then made one trailing flight; he approached her twice and attempted to mount her from the rear, but both times she sidestepped him. She then flew away, and he flew off in a different direction.

DISCUSSION

Nothing has been reported on male activity or mating behavior in the Miltogramminae. No sarcophagid, and possibly no calyptrate, is known to exhibit ritualized courtship (Downes, 1984, pers. comm.). Oldroyd (1964) notes that general behavioral patterns are repetitive throughout the Diptera. Therefore, an attempt has been made to associate references based upon the described behaviors of other fly species with those observed in this study for *Phrosinella aurifacies.*

Shortly after emergence, adults of *P. aurifacies* congregate to feed upon honeydew. They spend the night in the surrounding fields and leave in the early morning where they localize beside or beneath the aphid colonies. Downes (1983, pers. comm.) has also observed this species and *Gymnoprosopa milanoensis* Reinhard (Miltogramminae) feeding on honeydew. Sugar consumption by *P. aurifacies* males and females is obligatory because Miltogramminae need high concentrations of sugars to carry out their life activities (Downes, 1983, pers. comm.). *P. aurifacies* males manipulate honeydew-covered sand grains between their labella and foretarsal brushes, drop the grains, and then lap the brushes with their labella. A pheromone may be distributed by the male's foretarsal brushes. Honeydew so augmented could conceivably be used to attract conspecifics to feeding sites and thus assemble potential mates.

Because the males of *P. aurifacies* emerge first, they must wait in the area for the females. In many calyptrates and, perhaps all Sarcophaginae, the males congregate at station markers (Downes, 1983, pers. comm.). In *P. aurifacies* the males await female emergence in the area near honeydew. The females emerge, feed on honeydew, mate, and then oviposit/larviposit on the appropriate hosts. Thomas (1950) found that certain sarcophagids occur regularly at specific sites. He believes that particular environmental factors, perhaps food, limit a species to a locale and thus facilitate the meeting of the sexes.

Males of *P. aurifacies,* upon emergence, congregate at honeydew sites and, as their numbers increased, male-male encounters increase. Downes (1983, pers. comm.) has also noted that an abundance of males in a small area results in much chasing activity by virtue of "chain reactions" in which a single male leaving his perch induces others to follow. The station-taking territoriality (lekking) described for Hawaiian Drosophilidae (Spieth, 1952) was not evident in *P. aurifacies,* although males became more aggressive after female emergence.

Morphological sexual dimorphism exists in *P. aurifacies.* The males possess reduced foretarsi with foretarsal brushes and brightly pollinose fronses. Many families of more primitive dipterans, e.g., Culicidae, Dolichopodidae, Sepsidae, and Drosophilidae, contain species which also exhibit sexual dimorphism (Oldroyd, 1964). Spieth (1952) states that species of Hawaiian Drosophilidae not only possess a variety of morphological dimorphisms, e.g., on the foretarsus, -tibia and -femur, but also accompanying pigmentation dimorphisms involving the mouthparts, face, antennae, wings and legs. Each male dimorphism "is involved in the male's courtship behavior" (Spieth, 1952).

No sarcophagid is known to depend on visual patterns to discriminate a mate from an unsuitable one at close range (Downes, 1983, pers. comm.), but the bright golden pollinose frons of male *P. aurifacies* appears to function as a visual cue during stationary face-offs. After a male-male face-off, the males either return to feed, back-mount or crawl over, or one male chases the other away. After a male-female face-off, the male invariably commences courtship with wing-scissoring.

Elaborate male courtship displays are unknown for sarcophagids or calyptrates (Downes, 1983, pers. comm.), yet such precopulatory displays occur in other dipterans, e.g., mating flights in Sepsidae and Piophilidae (Oldroyd, 1964). Rau (1937) notes males and females of *Ptecticus trivittatus* Say (Stratiomyidae) hovering above garbage heaps during courtship. In addition, males of Piophilidae (Oldroyd, 1964), Drosophilidae (Brown, 1966; Spieth, 1952, 1974, 1978), and *Phrosinella fumosa* Allen (Downes, 1983, pers. comm.) circle 360° in hovering flights around a stationary female.

Wing waving is common among acalyptrates, and many males have conspicuously marked wings used to attract attention (Oldroyd, 1964). Such wing displays, which are a prerequisite to mating, may be visual and/or auditory and may involve one or both wings simultaneously, as in Drosophilidae (Brown, 1966; Bennet-Clark and Ewing, 1970; Spieth, 1952, 1974, 1978). In species where sound is the major element in mating, wing vibrations generate a species-specific sound during the wing upstroke, which the females sense with their antennal aristae (Bennet-Clark and Ewing, 1970).

In *P. aurifacies*, both wings scissor simultaneously and horizontally to the substrate. Often a male of *P. aurifacies* interrupts the scissoring to rub his antennae and lick with his mouthparts on the female's terminal abdominal segment (ovipositor?). Chemicals are known to function as precopulatory stimuli in the acalyptrates, e.g., females of *Sepsis* (Sepsidae) emit an odor that can be detected by humans (Oldroyd, 1964), and males of *Drosophila melanogaster* Meigen lick a female's ovipositor for species recognition (Spieth, 1952, 1974, 1978). *P. aurifacies* males may recognize a female in this manner.

An unreceptive (immature or already mated) female *P. aurifacies* eludes a male by flying through low vegetation. On the other hand, a receptive female may initiate trailing, yo-yo, or roller coaster flights. On occasion, when a male loses sight of a female, he returns to his last wing-scissoring station, and she sallies past him, perhaps indicating her receptivity. We found no mention of such behavior for any other fly species. *Drosophila* females exhibit acceptance by wing and/or genital spreading, ovipositor extrusion, or dancing (Brown, 1966; Spieth, 1974).

Aerial capture for mating is common but not universal in the Sarcophaginae (Downes, 1983, pers. comm.) and many other Diptera (Rau, 1937; Oldroyd, 1964). Moradeshaghi and Bohart (1968) state that *Euphyto* (= *Euphytomima*) *nomiivora* (James) males may either pounce directly from the air or land nearby and then jump on a female's back. Saccá (1964) states that, in *Musca*, "the union of the two sexes never takes place while flying." Similarly, in all sexual contacts by *P. aurifacies*, a male follows a female to the substrate and then climbs on her dorsum from the rear. The copulatory position assumed by *P. aurifacies* is similar to the median ventral position (Richards, 1927) of *Sarcophaga* sp. (Thomas, 1950), *Musca domestica* (Saccá, 1964), *Drosophila* spp. (Brown, 1966; Spieth, 1974, 1978), and *E. nomiivora* (Moradeshaghi and Bohart, 1968).

During copulation, a male of *P. aurifacies* periodically strokes a female's wings and body with his fore- and midlegs. His foretarsal brushes may play a part in this aspect of the courtship. The female responds by rubbing her own wings and abdomen with her hindlegs. Few accounts of other copulatory behavior have been recorded for dipterans. A *Ptecticus trivittatus* female, which assumes a position dorsal to the smaller male, caresses a male's frons and eyes with her forelegs; he responds by licking her legs with his proboscis (Rau, 1937). Moradeshaghi and Bohart (1968) make no mention of male behavior in *Euphyto nomiivora,* but state that a female intermittently stretches her legs and buzzes her wings during copulation. Males of *Musca domestica* caress a female's frons with their labella and, if she is receptive, she extrudes her ovipositor. If a *M. domestica* female is unreceptive, she kicks the male's wings with her midtibiae. *P. aurifacies* females exhibited similar behavior.

Copulation in *P. aurifacies* lasts from 3 to 26 min. Similar durations have been noted for *Euphyto nomiivora* (Moradeshaghi and Bohart, 1968). Downes (1983, pers. comm.) and Thomas (1950) state that, in Sarcophaginae, copulations last from as little as 4–5 min to over 4 h, but the shorter copulation times are atypical. According to Downes, copulations of short duration occur in species with enormous sperm pumps. He states that *Phrosinella* has one of the smallest sperm pumps in the family; therefore, the shorter copulations we observed in *P. aurifacies* may actually represent pseudocopulations (see Saccá, 1964). Moradeshaghi and Bohart (1968) report that a male of *E. nomiivora* will bend the end of his abdomen and attach it to a female's genital area to prevent successful approaches by other males. Such a pair, when disturbed, can separate immediately. Pairs *in copula* cannot be separated. Saccá (1964) states "the insemination reaction, consequent to the ejection of the spermatozoa into the vaginal sacs of *Musca domestica,* causes swelling of the latter, so at this moment the two sexes cannot part." This is probably true for *P. aurifacies* since one male was observed struggling to free himself from a female when interrupted *in copula.*

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THE GENUS *CELAENEPHES* SCHMIDT-GÖBEL: CHARACTERISTICS, SPECIES, AND RELATIONSHIPS (COLEOPTERA: CARABIDAE: LEBIINI)

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Abstract.—Based on structural features of adults, the Indo-Australian *Celaenephes* Schmidt-Göbel (type-species: *C. parallelus* Schmidt-Göbel, 1846) is included in a monobasic subtribe, Celaenephina, postulated to be the most ancestral of the known extant subtribes of Lebiini. Apotypic features of the Celaenephina include: lateral areas of elytra and ventral surface of body with a sparse vestiture of short setae; front and middle trochanters and stylomere 2 of the ovipositor each with unusually long setae; ventral surfaces of antennomeres 4–11 each with an ovoid pit containing numerous sense organs; left mandible without a terebral tooth, but with an anterior retinacular tooth; maxillary galeomere 2 with setae apically; labium with paraglossae broad, broadly adnate to glossal sclerite, and anterior margins truncate; metathoracic wing with shortened oblongum cell; and abdominal tergum VIII and sternum X markedly sclerotized. Alternatively, interpretation as apotypic of the seemingly plesiotypic features of body color, tarsi, pronotal shape, ovipositor, and male genitalia, plus the apotypic feature of setation of the elytra and the front coxal cavities possibly secondarily uniperforate, form the basis for considering *Celaenephes* as a close relative of the subgenus *Cymindis* Latreille. In addition to the type species, *C. parallelus* (junior synonyms, *C. foersteri* Bouchard, 1903 and *Fukuchina sanadai* Habu, 1960; range, the Indian sub-continent eastward to northeastern Australia, and northward through the Philippine Islands and Taiwan to the Japanese Archipelago), the genus includes *C. linearis* (Walker) (junior synonyms, *Taromorpha alternata* Blackburn, 1894 and *C. rechingeri* Csiki, 1915; range, Sri Lanka and India eastward through Burma, Indo-China and the Indo-Australian Archipelago to Australia, New Caledonia, the Solomon Islands and Samoa, and northward through the Caroline and Philippine Islands to the Ryukyu Archipelago). Adults of the two species are distinguished from one another by differences in color of appendages, details of the elytral surface, and form of the apices of the elytra. Males are further distinguished by differences in form of the middle tibiae and in form of the median lobe.

During the last century, men of nous were familiar with the classic languages. Even so, it seems remarkable that H. M. Schmidt-Göbel (1846: 77) knew and published the ancient word from Homeric Greek, "*Celaenephes,*" as a name for a seemingly non-descript lebiine adult. The word means "shrouded in dark clouds." Schmidt-Göbel did not explain why he chose this name, though the dark cuticle of specimens of this genus probably provided the required inspiration.

Such a name might also have implied uncertainty about relationships of this genus. However, the author specified that it was probably related to *Arsinoe* Laporte, suggesting that he was not troubled by concern about relationships. The name, nonetheless, was prophetic. Relationships of the genus were, in fact, uncertain. Lacordaire (1854: 138) included it in the Péricalides, a taxon now ranked as a subtribe (Pericalina) of Lebiini (Ball, 1975). Bates (1886: 211) considered *Celaenephes* as a cymindine, related to *Dromius*. Csiki (1932: 1412), Jedlička (1963: 299), and Habu (1967: 250) included this genus in the subtribe Dromiina. Basilewsky (1984: 528) stated that *Celaenephes* was certainly not a lebiine but rather a platynine. He did not indicate to what group of platynines *Celaenephes* was related.

Specimens were sufficiently obscure and thus difficult to characterize that the genus escaped the attention of some subsequent workers. Thus, Blackburn (1894: 85) proposed the generic name *Taromorpha* for a specimen of *Celaenephes* collected in eastern Australia, and Habu (1960) proposed the name *Fukuchina* for material of *Celaenephes* collected in Japan.

Problems with recognition of the genus were paralleled by problems with recognition of species. Six specific epithets were proposed in the following combinations: *C. parallelus* Schmidt-Göbel; *Leistus linearis* Walker, 1858; *Taromorpha alternata* Blackburn, 1894; *C. foersteri* Bouchard, 1903; *C. rechingeri* Csiki, 1915; and *Fukuchina sanadai* Habu, 1960. Bates (1886: 211) remarked, when synonymizing the names *Celaenephes parallelus* and *Leistus linearis* Walker that: "the reference of a Truncatipenne allied to *Dromius* to the genus *Leistus* must be considered one of Walker's greatest feats of random identification." Possibly so, but the seeming dark clouds that enshrouded *Celaenephes* may have obscured Walker's vision.

Andrewes (1930a: 81) listed *L. linearis*, *T. alternata*, *C. foersteri*, and *C. rechingeri* as junior synonyms of *C. parallelus*, and Habu (1967: 250) added *F. sanadai*.

Thus, in 1967, *Celaenephes* was recognized as a monobasic genus, within the subtribe Dromiina. Habu (*loc. cit.*, p. 210), however, noted that the features of the ovipositors of *Celaenephes* females were not consonant with ovipositors of other dromiines. Based on this consideration, Habu (1982: 113–114) removed *Celaenephes* from the Dromiina, erecting a new monobasic subtribe, Celaenephina, to include it. Ball and Hilchie (1983: 112, 204) independently reached this conclusion. Habu (*loc. cit.*, pp. 113–114) indicated that he regarded the celaenephine ovipositor as derived, having evolved toward more complete development of the stylomeres. Ball and Hilchie (*loc. cit.*, pp. 113–114) stated that the ovipositor was primitive, overall.

Two of the present authors (D.S. and G.E.B.) decided to review more extensively the position of *Celaenephes*, and in the process of examining some borrowed material, discovered that the genus included two different forms rather than only the one (*C. parallelus* Schmidt-Göbel), as recognized recently. At this stage, advice and assistance were sought from R. B. Madge; his contributions, communicated in letters and based on study of specimens in the collections at the British Museum (Natural History) and on examination of the literature, became sufficiently extensive to require including him as a third author. Together, we reviewed the evidence for recognition of the subtribe Celaenephina, and for the recognition of two species of *Celaenephes*, rather than one.

MATERIAL

This study was based on examination of 449 adult carabids representing the genus *Celaenephes*. As a basis for detailed comparison of character states of *Celaenephes*, 20 specimens of other taxa were dissected to verify published details, or to determine range of variation of particular features. These taxa were represented: *Calathus ingratus* Dejean, *Synuchus dubius* LeConte, and *Platynus decentis* Say (Tribe Platynini); *Peronoscelis latipennis* Chaudoir, and *Masoreus* species (Tribe Cyclosomini); and members of the tribe Lebiini—*Phloeoxena herculeano* Ball, and *Coptodera elongata* Chaudoir (subtribe Pericalina); *Apenes* species (subtribe Apenina); *Cymindis* (*Pinacodera*) *chevrolati* Dejean (subtribe Cymindina); *Euproctinus subdeletus* Bates (tentatively, subtribe Metallicina); *Agra* species (subtribe Agrina); *Gallerucidia erotyloides* Bates and *Calleida* species (subtribe Calleidina); *Dromius flohri* Bates (subtribe Dromiina); and *Lebia urania* Bates (subtribe Lebiina).

Specimens of *Celaenephes* were borrowed from the following institutions. Associated acronyms are used in the text to indicate source of particular specimens.

BMHH	Department of Entomology, Bernice P. Bishop Museum, 1355 Kalihi St., P.O. Box 19000-A, Honolulu, Hawaii 96819, U.S.A.
BMNH	Department of Entomology, British Museum (Natural History), Cromwell Road, London SW7 5BD, England
CAS	Department of Entomology, California Academy of Sciences, Golden Gate Park, San Francisco, California 94118, U.S.A.
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts 02138, U.S.A.
RTB	R. T. Bell Collection, Department of Zoology, The University of Vermont, Burlington, Vermont 05405, U.S.A.
SMNH	Section of Entomology, Swedish Museum of Natural History, S-104 05 Stockholm, Sweden
USNM	Department of Entomology, United States Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, U.S.A.

Type material was loaned to us by the Department of Entomology, National Museum in Prague, Czechoslovakia.

METHODS

Material used for detailed comparison was restricted to the Tribe Platynini, and to those lebiine subtribes with which *Celaenephes* had been associated: Pericalina, Cymindina, and Dromiina. We noted in passing characteristics of other subtribes (Apenina, Metallicina, Calleidina, Agrina, and Lebiina), but did not record information about them because such was not essential for our study.

Because of the nature of this study, no attempt was made to obtain all available material of *Celaenephes,* nor to assess in detail intraspecific variation. Rather, we worked with material that was readily available which we judged in terms of experience with other taxa to be adequate for our purposes.

For comparison, we used few representatives of other taxa, choosing for study characters about whose range of variation something was known. We assessed variation of few characters, principally those used by previous authors in establishing higher taxa of Lebiini. We examined as well a few autapotypic traits of *Celaenephes.*

Taxonomic and phylogenetic principles, criteria used for ranking taxa, and general working methods were the same as those previously described (see Ball and Shpeley, 1983), and are not repeated here.

Genitalia and sclerites of ovipositors were preserved in glycerine, in microvials. Mouthparts and wings that were removed were glued on small cards. Microvials and cards were pinned beneath the specimens from which the sclerites had been removed.

For examination and illustration of some structures, a stereo-electron microscope, Cambridge Model S-150, was used. Specimens were cleaned using a sonicator, and were then gold-coated.

Terms for Structures

In addition to words established by years of general usage, we have used several that have so far appeared principally in publications about carabids. Attention is drawn to them here, in the interest of clarity.

For micro-units of surface sculpture bounded by lines of microsculpture ("micro-lines"), we use "sculpticell" (Allen and Ball, 1980: 486); for elytral stria, "interneur" (Erwin, 1974: 3–5). For abdominal terga and sterna, Roman numerals are used, the first visible sternum being II, and the last one that is normally not retracted, VII.

Sclerites and setae of the ovipositor are named according to a system fully explained by Ball and Shpeley (1983: 746–749). Surfaces are named according to their orientation with the ovipositor fully extended, rather than retracted. The retracted condition is seen in most dead specimens, and is the way that the ovipositor is carried except when in use. Thus, the surface that is ventral in the retracted position is lateral with the ovipositor extended, and is named accordingly, with other surfaces named correspondingly.

Two structures not previously noted in carabids were found; they are as follows. On the ventral surfaces of antennomeres 4–11, pits were noted, each containing a number of structures that seem to be sensory (Fig. 12). These cavities are named "sensory pits." On the ventral surface of each mandible is a groove that houses numerous pores, each with a filament (Fig. 17). Because these filaments seem to be secretions, the grooves containing them are named "secretory grooves."

Subtribe Celaenephina

Recognition.—Adults of this group have the following combination of putatively apotypic (derived) character states: elytron with apical fringe of microsetae; ventral surface with sparse vestiture of short setae; front and middle trochanters each with a long seta; antennomeres 4–11 ventrally each with pit containing sensory organs (Fig. 12); left mandible with an anterior retinacular tooth, without terebral tooth (Figs. 15A, B); each mandible ventrally with a secretory groove (Figs. 15B, 16B, 17A, B); galeomere 2 of maxilla with apical half setose (Fig. 13); labium with paraglossae adnate to glossal sclerite (Fig 14); elytra with apices subtruncate; tergum VIII completely sclerotized, without membranous area medially (Fig. 7); (cf. Figs. 24–26); sternum X sclerotized (Fig. 10). Females have the nematoid setae as long or longer than stylomere 2 (Figs. 21A, C).

Included taxa.—This subtribe includes only the genus *Celaenephes* Schmidt-Göbel.

Relationships.—This subtribe is here suggested to be the most ancestral group of extant lebiines, and the sister group of the remaining subtribes. Details supporting this hypothesis are presented, following taxonomic treatment of the genus and species.

Geographical distribution.—The range of this Old World subtribe extends from Sri Lanka and India eastward in the Oriental Region through the Indo-Australian Archipelago to eastern Australia, New Caledonia, and the Samoan Archipelago. Northward, the range extends through the Philippine Archipelago and Taiwan to the southern part of the Japanese Archipelago (cf. Figs. 22 and 23).

Celaenephes Schmidt-Göbel

Celaenephes Schmidt-Göbel, 1846: 78–79. TYPE SPECIES: *Celaenephes parallelus* Schmidt-Göbel, 1846: 78 (by monotypy).—Lacordaire, 1854: 138.—Bates, 1892: 420.—Andrewes, 1927a: 272.—1927b: 11.—1930a: 81.—1930b: 337.—Csiki, 1932: 1412.—Jedlička, 1963: 299.—Habu, 1967: 249–250.—Darlington, 1968: 135.—Habu, 1982: 113–114.—Ball and Hilchie, 1983: 112 and 204.

Taromorpha Blackburn, 1894: 85. TYPE SPECIES: *Taromorpha alternata* Blackburn, 1894: 85 (by monotypy).—Andrewes, 1927a: 272.

Fukuchina Habu, 1960: 4–5. TYPE SPECIES: *Fukuchina sanadai* Habu, 1960: 5–6 (by monotypy).—Jedlička, 1963: 430–431.—Habu, 1967: 249.

Notes about synonymy.—Andrewes (1927a: 272) synonymized the names *Taromorpha* and *Celaenephes* without presenting supporting statements. We have seen type material of both type species and believe that they are congeneric.

Habu (1967: 249) synonymized the names *Fukuchina* and *Celaenephes*. We have not seen the holotype of *F. sanadai* Habu, but illustrations of type material (*loc. cit.*, figs. 421–428) show that Habu (1960) had in hand specimens of *C. parallelus* on which he based the description of the type species of *Fukuchina*.

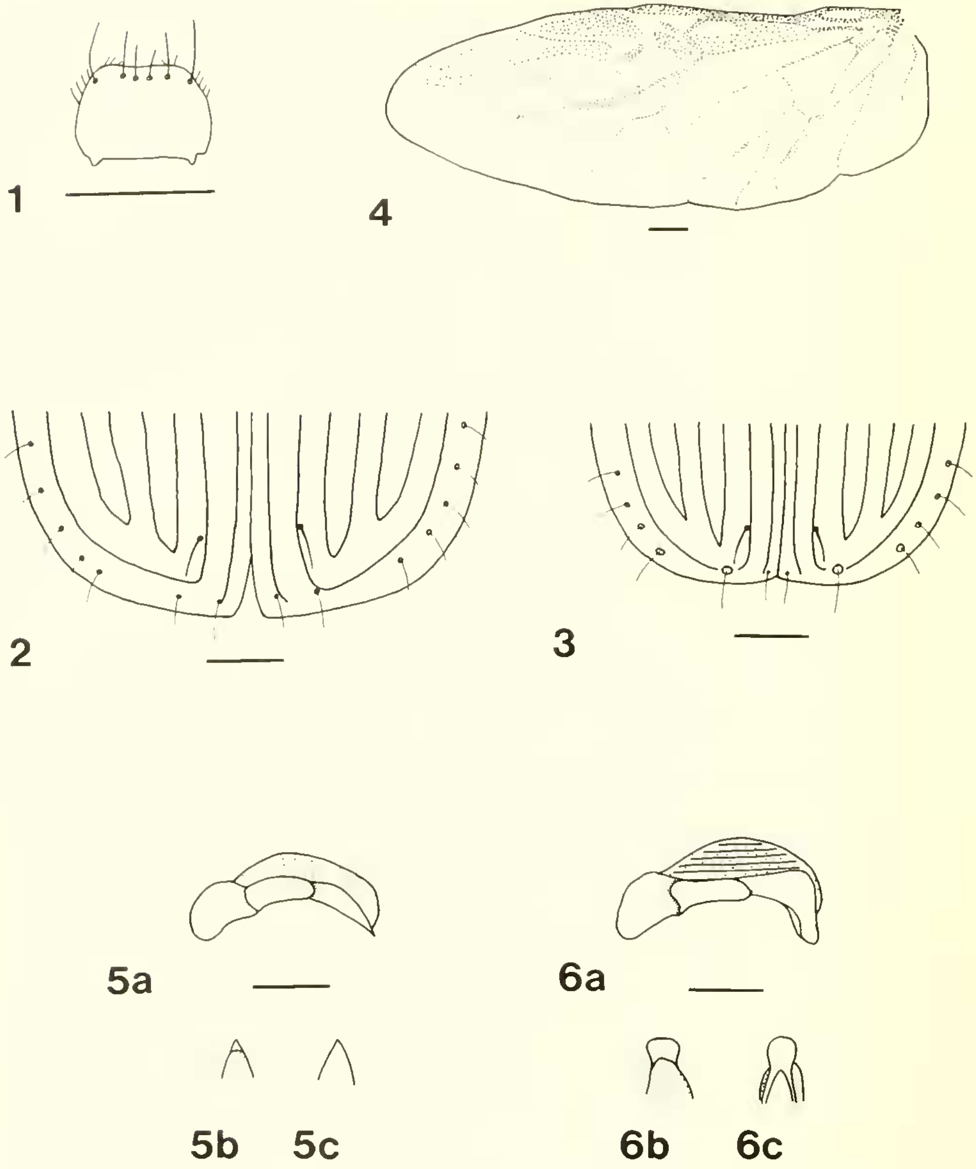
Description.—Standardized Body Length 5.32–7.36 mm (males) and 5.60–7.16 mm (females).

Color.—Head, thorax, and abdominal sterna castaneous to black, antennae and mouthparts testaceous to black.

Microsculpture.—Dorsal surface with mesh pattern isodiametric, microlines faint on clypeus, frons, vertex, and disc of pronotum; more easily seen laterally on pronotum and elytra. Ventral surface with mesh pattern slightly transverse on head near eyes, thoracic sterna, pterothoracic pleura, and abdominal sterna medially; isodiametric on proepisternum and abdominal sterna laterally; microlines not evident medially on head.

Luster.—Surface moderately shining.

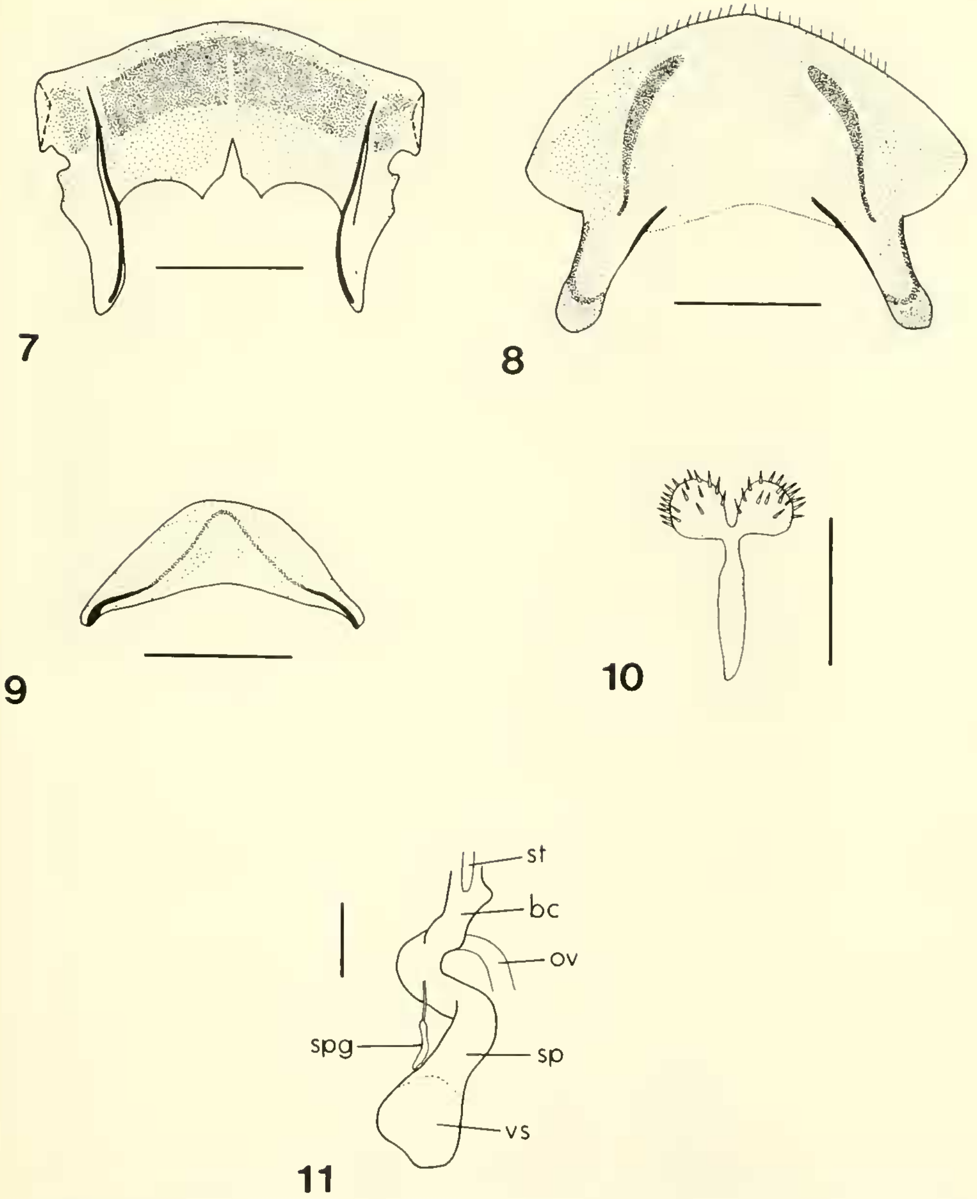
Fixed setae.—Typical for Lebiini, those of fore and middle trochanters longer than normal.



Figs. 1–6. Line drawings of sclerites of *Celaenephes* adults (scale bars = 0.50 mm). 1, labrum of *C. linearis*. 2–3, Apices of elytra: 2, *C. parallelus*; 3, *C. linearis*. 4, Left hind wing of *C. linearis*. 5–6, Male genitalia (A, median lobe and left paramere, left lateral aspect; B and C, median lobe, dorsal and ventral aspects, respectively). 5, *C. parallelus*. 6, *C. linearis*.

Vestiture.—Elytra with intervals 7, 8, and 9 with sparse covering of fine short setae. Ventral surface of head with few fine setae near eyes. Palpomeres, thoracic and abdominal sterna and metepisterna finely setose. Fore coxae with few short setae. Middle coxae with numerous moderately long and few markedly longer setae. Hind coxae with lateral-posterior margins fringed with numerous long setae. Tarsomeres with dorsal surfaces setose.

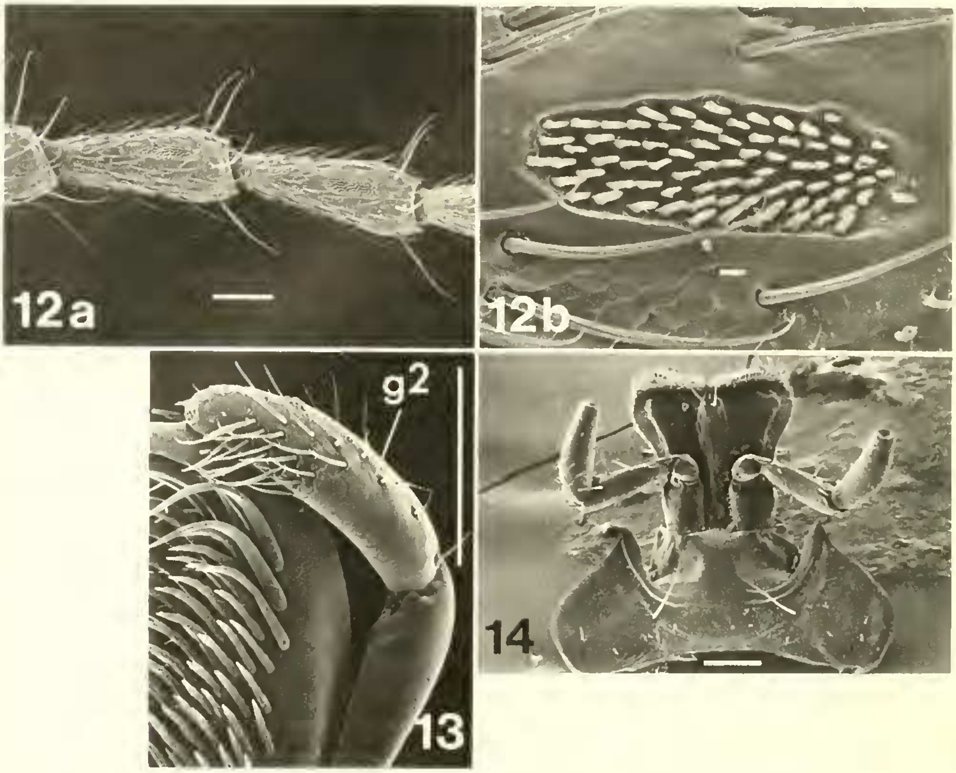
Head.—Labrum as in Fig. 1. Frons smooth with fine punctures. Clypeus rect-



Figs. 7–11. Line drawings of structures of *Celaenephes linearis* adults (scale bars = 0.50 mm). Figs. 7–10, terminal abdominal sclerites. 7, Tergum VIII. 8, Sternum VIII. 9, tergum X. 10, Sternum X. 11, Female reproductive tract and associated sternum X, dorsal aspect. (bc, bursa copulatrix; ov, oviduct; sp, spermatheca; spg, spermathecal gland; st, sternum X; vs, ventral sclerite).

angular, with anterior margin straight. Eyes large, subgenae very small. Antennae of average length, extended beyond base of pronotum. Antennomeres 2 and 3 each with ring of setae apically, few fine setae scattered over surface. Antennomere 4 setose in apical three fourths; antennomeres 5–11 generally setose. Antennomeres 4–11 each with ventral sensory pit (Figs. 12A, B).

Mouthparts.—Left mandible (Figs. 15A, B) with cutting edge formed by retinac-



Figs. 12–14. SEM photographs of sclerites of *Celaenephes* adults. 12, Antenna, ventral aspect, of *C. linearis.* (A, antennomeres 7–10 (scale bar = 100 μm); B, antennomere 9, enlargement to show detail of sensory pit (scale bar = 5 μm). 13–14, Mouthparts of *C. linearis.* 13, Left maxilla, ventral aspect (scale bar = 100 μm), g2, galeomere 2. 14, labium ventral aspect (scale bar = 100 μm).

ular ridge; posterior retinacular tooth prominent; anterior retinacular, premolar, and molar teeth present. Right mandible (Figs. 16A, B) with cutting edge formed by terebral ridge; terebral, retinacular, premolar and molar teeth present. Both mandibles ventrally with long secretory groove (Figs. 17A, B). Maxillae average for Lebiini; galeomere 2 setose near apex (Fig. 13); maxillary palpomere 4 fusiform, subequal in length to palpomere 3. Labium with ligula (Fig. 14) with large membranous paraglossae, densely setose along lateral margins, broadly adnate to glossal sclerite; latter narrow, with two long setae apically; labial palpomere 3 fusiform, subequal in length to bisetose palpomere 2; mentum edentate.

Thorax.—Pronotum slightly convex, wider than long; anterior margin slightly concave, posterior margin slightly convex; anterior angles rounded, posterior angles obtuse; lateral margins reflexed; side sinuate before posterior angles. Pro-

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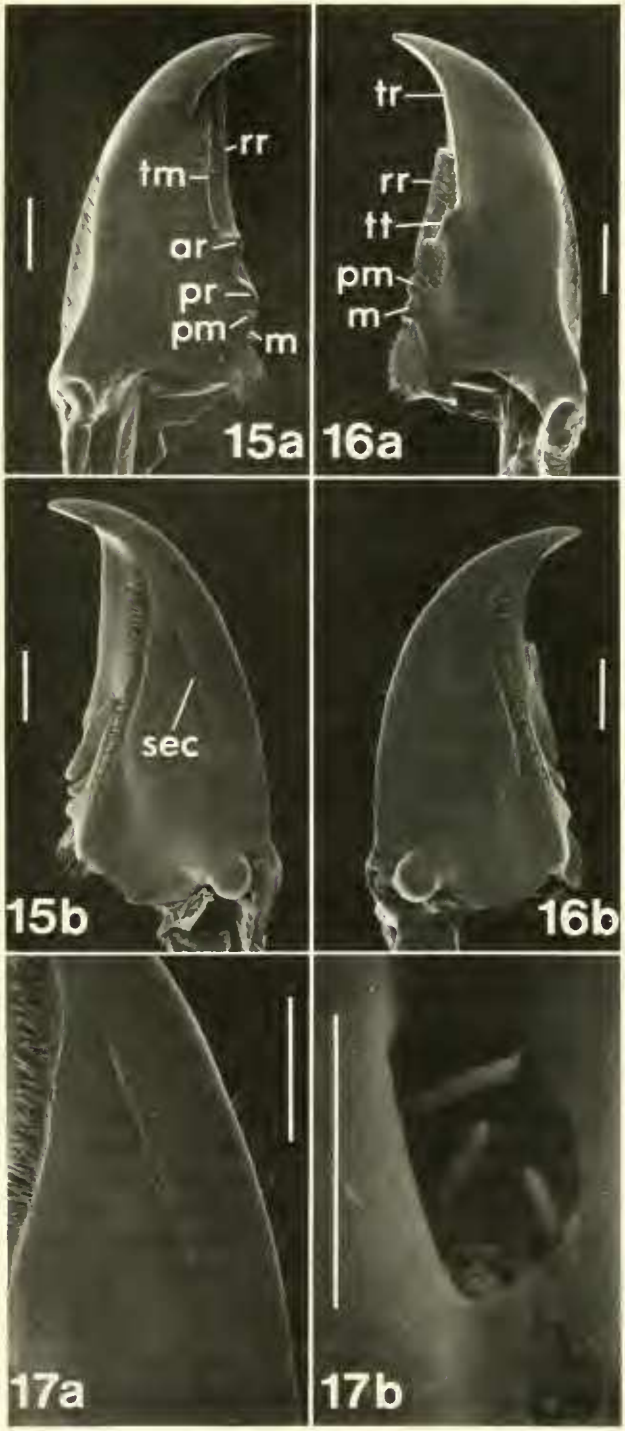
Figs. 15–17. SEM photographs of mandibles of *C. linearis* adults. 15A and B, left mandible, dorsal and ventral aspects, respectively. 16A and B, Right mandible, dorsal and ventral aspects, respectively (scale bars = 100 μm) (ar, anterior retinacular tooth; m, molar; pm, premolar tooth; pr, posterior



retinacular tooth; rr, retinacular ridge; sec, secretory groove; tm, terebral margin; tr, terebral ridge; tt, terebral tooth). 17A, Portion of left mandible, ventral aspect, showing secretory groove (scale bar = 100 μm); 17B, enlargement of 17A, showing detail of secretory groove (scale bar = 2 μm).

sternum with intercoxal process bisetose. Anterior coxal cavities uniperforate. Pterothorax with metepisternum elongate, lateral margin about twice as long as anterior margin.

Elytra.—Widened apically; apical angle either obtuse and preapical angle slightly rounded (Fig. 2), or apical angle nearly rectangular, and preapical angle markedly rounded (Fig. 3). Interneurs shallow; intervals broad, only slightly convex. Interval 3 with three setigerous punctures. Interval 4 uniformly convex, or depressed medially. Umbilical series with 22 or fewer (average 20) setigerous punctures. Basal ridge incomplete (Fig. 18A), extended only to near base of interneur 4; apex with fringe of fine setae (Fig. 18B).

Hind wings.—Fully developed, oblongum cell reduced, wedge cell present (Fig. 4).

Legs.—Long and slender, hind tarsus and tibia subequal (length hind tarsus/length hind tibia = 0.85) in length. Middle tibia of male either unmodified (Fig. 20), or with notch in ventral surface (Fig. 19). Males with tarsomeres 1–3 of front leg with adhesive vestiture biseriate. Tarsal claws smooth, not pectinate.

Abdomen.—Sterna IV, V, and VI each with one pair of long (ambulatory) setae. Sternum VII of male with one pair of anal setae, female with two pair. Tergum VIII (Fig. 7) sclerotized throughout; sternum VIII (Fig. 8) membranous medially. Tergum X as in Fig. 9; sternum X (Fig. 10) well developed.

Male genitalia.—Median lobe slender, dorsal surface to basal bulb membranous, membrane either smooth (Fig. 5A) or carinate; apex in ventral aspect slender and pointed (Figs. 5B, C), or thickened and broadly rounded (Figs. 6B, C); apical orifice dorsal. Internal sac without armature. Parameres subequal in length, apices of each broadly rounded.

Ovipositor.—Stylomere 1 setose medially near apex (Fig. 21A). Stylomere 2 (Figs. 21A, B) falcate, with broadly rounded apex; one dorsal ensiform seta medially, two to four laterally; nematoid setae as long or longer than stylomere 2.

Female genitalia.—*Bursa copulatrix* reduced; spermatheca very large, with terminal sclerite ventrally; spermathecal gland present (Fig. 11).

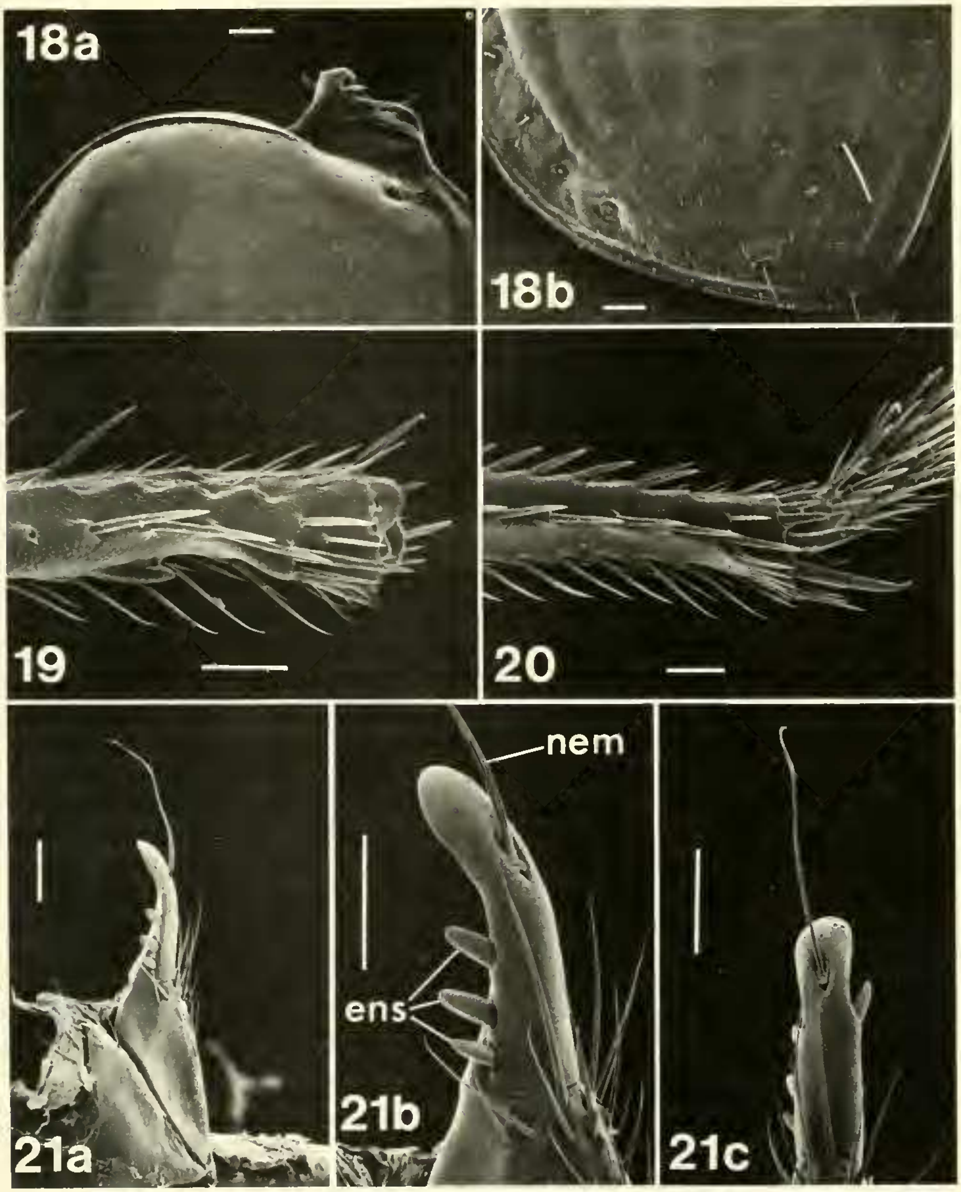
KEY TO SPECIES OF *CELAENEPHES* SCHMIDT-GÖBEL, BASED ON FEATURES OF ADULTS

1. Terminal palpomeres with only apices pale, latter markedly contrasted with dark bases. Elytron with interval four even, surface not depressed at middle. Middle tibia of male with inner (i.e., ventral) margin with single deep notch, preapically (Fig. 19), and median lobe of genitalia with apex pointed (Figs. 5B, C) .... *C. parallelus* Schmidt-Göbel.

– Terminal palpomeres pale, almost without contrast between base and apex. Elytral interval 4 of most specimens with shallow depression at middle. Male with inner margin of middle tibia with series of shallow emarginations (Fig. 20), and median lobe of genitalia with apex broad (Figs. 6B, C) .... *C. linearis* (Walker).

Celaenephes parallelus Schmidt-Göbel

Celaenephes parallelus Schmidt-Göbel 1846: 78–79. TYPE MATERIAL: one male and three females. LECTOTYPE (here selected), male, labelled: MUS. PRAGENSE TENASSERIM COLL. HELFER; Typus! teste Dr. J. Obenberger



Figs. 18–21. SEM photographs of sclerites of *Celaenephes* adults (scale bars = 100 μm). 18, Left elytron, dorsal apsect, of *C. linearis*. (A, base; B, apex). 19–20, Middle tibiae, anterior aspect, apical portion. 19, *C. parallelus*. 20, *C. linearis*. 21, Left stylomeres 1 and 2 of ovipositor of *C. linearis*. (A, stylomeres 1 and 2, lateral aspect; B and C, stylomere 2, lateral and ventral aspects, respectively; ens, ensiform setae; nem, nematoid setae (scale bars = 100 μm)).

[red paper]; parallelus Sch. G. COL. HELFER [handwritten above type]; Mus. Nat. Pragae Inv. 26638 [orange paper]; PARALECTOTYPES: two females, Nos. 26636 and 26637 labelled as above. One female labelled: MUS. PRAGENSE COLL. HELFER; Burma Helfer [handwritten]; Typus! teste Dr. J.

Obenberger [red paper]; parallelus Sch. G. COL. HELFER [handwritten above type]; Mus. Nat. Pragae Inv. 26635 [orange paper] (National Museum in Prague, Czechoslovakia). TYPE LOCALITY: Burma, Tenasserim.—Bates, 1886: 211.—1892: 420.—Andrewes, 1919: 188.—1923: 46.—1927a: 272.—1927b: 11.—1929: 314.—1930a: 81.—1930b: 337.—1947: 12.—Csiki, 1932: 1412.—Landin, 1955: 405, 466.—Jedlička, 1963: 399–400.—Habu, 1967: 250–253.—Darlington, 1968: 135.

Celoenephes (sic) parallelus; Bouchard, 1903: 176.—Habu, 1967: 251.

Coloenephes (sic) foersteri Bouchard, 1903: 176. TYPE MATERIAL: Not seen. TYPE AREA: Sumatra.—Andrewes, 1927b: 11.—1930a: 81.

Fukuchina sanadai Habu, 1960: 5–6. TYPE MATERIAL: not seen. HOLOTYPE female, labelled: VIII.7, 1956 Mt. Fukuchi K. Sanada leg. TYPE LOCALITY: Fukuoka Prefecture, North Kyushu, Japan.—Jedlička, 1963: 430–431.—Habu, 1967: 251.

Celaenephes parallelus (in part); Darlington, 1968: 135.

Notes about synonymy.—Andrewes (1930a: 81) synonymized the names *C. parallelus* and *C. foersteri.* We have not seen type material of the latter named form, but accept the synonymy, reasoning as follows. Bouchard compared the character states of *C. foersteri* with those of *C. parallelus,* and from the statements made, we believe that Bouchard identified specimens of *C. linearis* (Walker) as *C. parallelus.* Thus, Bouchard's new species was the true *C. parallelus,* the specimens in question being smaller and darker. Habu (1967: 250) synonymized the names *F. sanadai* and *C. parallelus.* For further details, see synonymical notes under the genus *Celaenephes.*

Recognition.—In addition to features presented in the key, adults have piceous to black antennae and mouthparts, and the sutural angle of the elytron is rounded (Fig. 2). Standardized Body Length ranges as follows: 5.32–6.04 mm (males) and 5.60–6.60 mm (females).

Notes about habitat and life history.—Adults of this species are probably arboreal, as are those of *C. linearis.* However, only one specimen (from New Guinea) that we have seen is associated with habitat data: "on maize leaf." Because maize is an introduced species of plant, the association of it and *C. parallelus* may be evidence that the latter species can survive in habitats disturbed by man.

Collecting records extend from May to November, and specimens have been collected at light from May to September. Adults may be active fliers throughout the year, but this cannot be established from the few available records.

Remarks about *C. parallelus* by Darlington (1968: 135) refer principally to *C. linearis.*

Geographical distribution (Fig. 22).—The range of this species extends from India (Amalai Hills, Madras [B. P. Moore, personal communication]) to northeastern Australia, and through the Philippines and Taiwan to Kyushu Island in the Japanese Archipelago. (The Australian specimens [male and three females] were collected at Cardstone, North Queensland, November 15–28, 1966 [B. P. Moore, CSIRO, personal communication]). The seemingly isolated occurrences of *C. parallelus* in New Guinea and Australia are likely to be artifacts of collecting, rather than representing populations far removed from the other populations of the species.

Chorological affinities.—The ranges of *C. parallelus* and *C. linearis* overlap

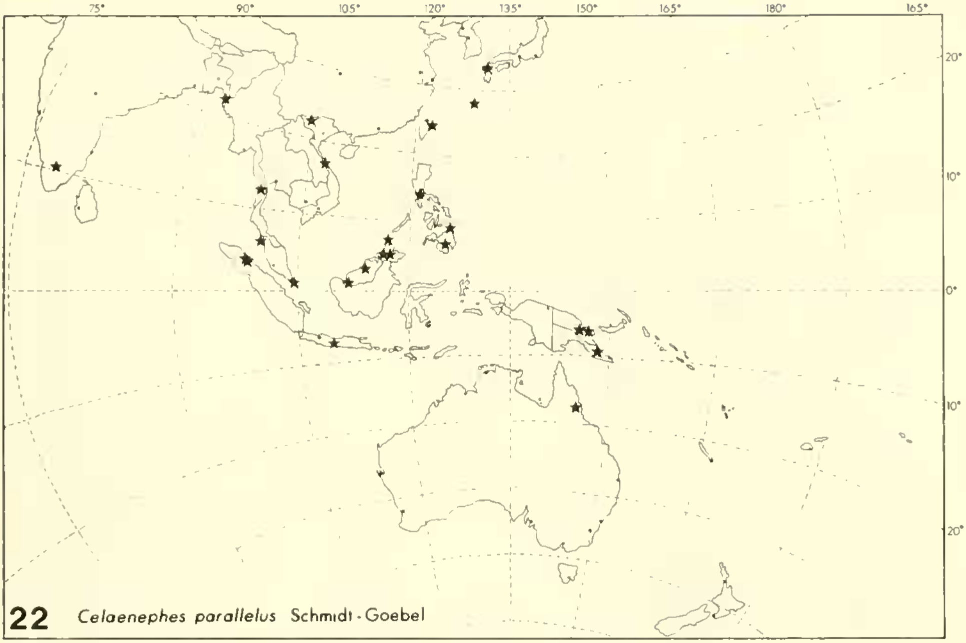


Fig. 22. Geographical distribution of *Celaenephes parallelus.*

broadly (*cf.* Figs. 22 and 23). Furthermore, both species have been taken at the same localities in Burma, Viet Nam, the Philippine Islands, Sabah, Sarawak, the Riouw Archipelago off Sumatra, New Guinea, and Australia. Such extensive sympatry, both general and specific, provides good presumptive evidence that the two forms, established on morphological differences, are indeed reproductively isolated from one another, and hence are specifically distinct. However, the extensive overlap prevents inferring the location or nature of the barrier that led to the differentiation of the ancestral stocks of the two species. It remains to be determined if they occupy different habitats, and the role of structural differences in maintaining their reproductive isolation.

Material examined.—We have seen 42 specimens including types of this species. Non-type material was seen from the following localities: BANGLADESH. Sitapahar R., Chittagong, H.T. (BMNH). BURMA. Myitkyina, 175 m (SMNH). Tenasserim (BMNH). INDONESIA Java. Djeroeklegi, Zuid-Banjoemas (BMNH). Sumatra. Riouw Arch. (BMNH). Sumatra's O.K., Soengei Merah (BMNH). Tijinta Radja (BMNH). MALAYSIA Sabah-Borneo. Borneo North (BMNH). 5 mi S Mt. Trus Madi, 1800 ft (BMNH). R. Karamuak, 7 mi SSE Telupid (BMNH). Tawai Plat., 8 mi S Telupid, 1300 ft. (BMNH). Sarawak-Borneo. foot of Mt. Dulit, jct. of rivers Tinjar & Lejok (BMNH). LUBOK ANTU (BMNH). Malaya. Penang. (BMNH). PAPUA. New Guinea. Goroka, 1550 m (MCZ). Madang Dist., Finisterre Mts., 3500 ft (BMNH). Oro Bay (MCZ). Popondetta (MCZ). Wabag (RTB). Wau (RTB). PHILIPPINE ISLANDS. Balabac (BMNH). Mindanao I.: (BMNH); Davao (BMNH) (USNM); Surigao (BMNH) (USNM). Luzon I., Laguna, Mt. Makiling (CAS). VIET NAM. Quang Tri Prov.: 1 mi N Quang Tri (USNM); Cam Lo, 7 mi W Dong Ha (USNM). Tonkin, Chapa (BMNH).

Celaenephes linearis (Walker)

Leistus (?) *linearis* Walker, 1858: 203. HOLOTYPE male, labelled: Type, H. T. [white disc, ringed with red]; Ceylon [handwritten, on pale blue disc], 59 106 [on under surface]; Leistus? linearis Walker Ann. N. Hist. (Type) [handwritten, on blue paper] (BMNH). TYPE AREA: Ceylon.—Bates, 1886: 211.—Andrewes, 1919: 188.—1927b: 11.—1930a: 81.—Csiki, 1932: 1412.—Habu, 1967: 250.

Taromorpha alternata Blackburn, 1894: 85. HOLOTYPE male, labelled: 4997 Cairns [handwritten in red ink on card supporting specimen]; Type [white disc, ringed with red]; Australia, Blackburn Coll., B.M. 1910-236; Taromorpha alternata, Blackb. [handwritten]. (BMNH). TYPE LOCALITY: Cairns, Australia. NEW SYNONYMY.—Andrewes, 1927a: 272.—1927b: 11.—1930a: 81.—Csiki, 1932: 1412.—Jedlička, 1963: 399.—Habu, 1967: 250.

Celaenephes rechingeri Csiki, 1915: 164. LECTOTYPE (here selected) teneral male, labelled: Upolu Samoa Rechinger; Celaenephes Rechingeri m. Typus! [in red ink] det. Csiki [handwritten]; borrowed fr. Budapest Mus. (MCZ). PARALECTOTYPE female, labelled: Savaii Samoa Rechinger '05; Celaenephes Rechingeri m. Typus! [in red ink]; det. Csiki [handwritten]; borrowed fr. Budapest Mus. (MCZ). PARALECTOTYPES (sex not determined), labelled as above, one from Savaii, two from Upolu (Naturhistorisches Museum Wien).—TYPE LOCALITY: Samoa, Upolu Island. NEW SYNONYMY.—Andewes, 1927b: 11.—1930a: 81.—Csiki, 1932: 1412.—Jedlička, 1963: 399.—Habu, 1967: 251.

Celaenephes parallelus (in part); Habu, 1967: 251.—Darlington, 1968: 135.—1970: 43.

Notes about synonymy.—Bates (1886: 211) synonymized *Leistus linearis* Walker with *C. parallelus* Schmidt-Goebel. This action was incorrect, for the holotype of *L. linearis* is clearly specifically distinct from the type of *C. parallelus.*

We have examined the types of *T. alternata* Blackburn, and *C. rechingeri* Csiki, and both are conspecific with the holotype of *L. linearis.*

Jedlička (1963: 399) records the location of the type of *C. rechingeri* as the Berlin Museum. However, we have seen specimens labelled as "type" in the Naturhistorisches Museum Wien, and in the MCZ; evidently Csiki labelled all of the specimens that he saw as "type." Thus, a lectotype designation is required, and we have provided one.

Recognition.—In addition to features presented in the key, adults have testaceous to castaneous antennomeres and mouthparts and the sutural angle of the elytron is nearly rectangular (Fig. 3). Standardized Body Length ranges as follows: 6.00–7.36 mm (males) and 5.92–7.16 mm (females).

Notes about habitat and life history.—Specimens of this species have been taken in a variety of habitats, as indicated by data on locality labels: in bases of bromeliad leaves (*sic*); beating trees; moss forest; undergrowth, secondary forest; and near fermenting tapioca.

Specimens have been collected throughout the year, but only from June to September north of the equator, and July to October south of the equator, at white or ultra-violet light. We have seen teneral specimens which were collected in June, July, and August in New Guinea, and in October and November in Australia.

Darlington (1968: 135) suggested that adults of *Celaenephes* may have reached

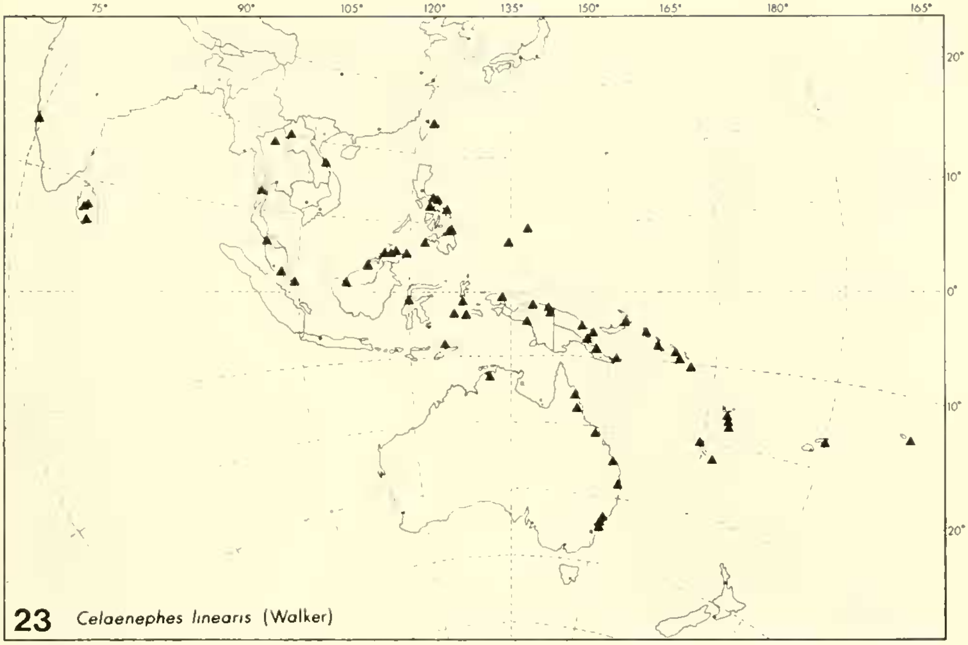


Fig. 23. Geographical distribution of *Celaenephes linearis.*

the Pacific islands by transportation in thatching material, this being a consequence of an arboreal way of life. Not recognizing that two species were included in the genus, he referred to *C. parallelus* only, though it is *C. linearis* that ranges into the Pacific Islands.

Geographical distribution.—The range of this species extends from Sri Lanka and India (Shimoga, Agumbe Ghat [B. P. Moore, CSIRO, personal communication]) in the Oriental Region eastward throughout the Indo-Australian Archipelago to the Samoan islands of Upolu and Savaii; southward to the northern and eastern coasts of Australia (including Cardstone, N. Queensland [B. P. Moore, CSIRO, personal communication]), and to New Caledonia. Northward, the range of *C. linearis* extends to Iriomote, the southernmost island of the Ryukyu Archipelago. The last-named record is based on fig. 425 (Habu, 1967: 252), which illustrates the apical portion of an elytron. Although Habu identifies the specimen as *C. parallelus,* the form of the elytron is characteristic of *C. linearis.* This species is also known from the Western Caroline Islands, the records being under the name *C. parallelus* (Darlington, 1970: 43).

Chorological affinities.—See this topic under *C. parallelus.*

Material examined.—We have seen 388 specimens including types. Non-type material was seen from the following localities: AUSTRALIA. New South Wales: Illawarra (BMNH); Newport, N. Sydney (BMNH); Ryde, W. Sydney (BMNH). Northern Terr., Stuart Hwy., Coomalie Ck. (CAS). Queensland: Cedar Ck. Falls, Tamorine (CAS); Eubenangee (BMNH); 8 mi NE Eungella, 950 m (CAS); 17 mi W Monto, 500 m (CAS). BURMA. Tenasserim (BMNH). FIJI ISLANDS. Taveuni (BMNH). Wainganitu (MCZ). INDONESIA Celebes. (BMNH). Lesser Sundas.

Poera, Ins. Allor, 3000–4000 ft. (BMNH). Moluccas. Amboina (BMNH). Buru (BMNH). Laiwui (BMNH). Sumatra. Riouw Arch. (BMNH). West Irian-New Guinea. Bodem, Saroni area (MCZ). Cyclops Mts., Sabron, 930 & 1200 ft. (BMNH) (MCZ). Hollandia (BMNH) (MCZ). Launch Camp, Setakwa Utakwa Exped. (BMNH); Maffin Bay (BMNH) (MCZ). Maffin Bay, Mt. Leamington, 1300–1500 m (MCZ). Njau-limon, S of Mt. Bougainville, 300 ft. (BMNH). Santani (MCZ). Vogelkop, Kebar Valley, w Manokwari, 550 m (MCZ). Waris, 450–500 m (MCZ). MALAYSIA Malaya. Casteln (BMNH). Malacca (BMNH). Talan Lintok, N. Kedah (BMNH). Sabah-Borneo. Borneo North (BMNH). R. Karamauk, 7 mi SSE Telupid, 200 ft (BMNH). Sandakan (BMNH)(USNM). Sook., 17 mi SE Keningau, 1500 ft. (BMNH). Tawai Plat., 8 mi S Telupid, 1300 ft. (BMNH). Sarawak-Borneo. (BMNH). DRTU's ROAD (BMNH). Kuching (BMNH). Mt. Dulit (BMNH). foot of Mt. Dulit, jct. of rivers Tinjar & Lejok (BMNH). Mt. Matang., 500–1000 ft. (BMNH). NEW CALEDONIA. (BMNH). Boulopuari, Oenghklu R. (MCZ). Plaine des lacs (BMNH). Puebo coast, 1500 ft. (BMNH). Tinchialit, 2020 ft. (BMNH). PAPUA Bougainville Island. Piva River (MCZ). New Britain Island. Gazelle Peninsula, Upper Warangoi, 220 m. (MCZ); Matupi (MCZ). New Guinea. Binigusi, Gwariu R., 150 m (MCZ). Cape Killerton (MCZ). Dobadura (MCZ). Erima, Astrolabe Bay (MCZ). Finschafen (CAS)(MCZ). Ishurava, 3000 ft. (BMNH). Kokoda, 1200 ft. (BMNH). Morobe District: Kunai Creek (MCZ); Surprise Creek (MCZ); Wau (MCZ)(RTB); forestry road north of Wau (CAS). Wabag (RTB). Noramanby Island, Waikuna, Sewa Bay (MCZ). Popondetta (MCZ). PHILIPPINE ISLANDS. Basilan I. (BMNH)(USNM). Island Samar (USNM). Island Sibuyan (BMNH)(USNM). Luzon I.: Calabangan (CAS); Malinao, Tayabas (BMNH). Mindanao I.: Kabasalan, Zamboanga (CAS); Surigao (BMNH)(MCZ)(USNM). Sanga Sanga, Moorjawa (BMNH). SAMOA. Upolu, Apia (BMNH). SOLOMON ISLANDS. Guadalcanal I.: (MCZ); Honiara (BMNH)(CAS); Matanikau River (MCZ); Tapenanje, 1100 ft. (BMNH); Tenaru River (MCZ). Kolombangara I., Ringi Cove, 23–24 km up main road (CAS). San Cristobal Island, Wainoni (BMNH). San Jorge (BMNH). SRI LANKA. Balangoda (BMNH). Gal District, Udugama Kanneliya Jungle, 240 m. (USNM). Mon. District, Monaragala (USNM). Pol District, Sigirya (USNM). THAILAND. E slope, Doi Sutep, 260 m (CAS). VANUATU (= New Hebrides). Aneityum (BMNH). Malekula I. (BMNH). Tanna (BMNH). VIET NAM. Quang Tri Prov., Cam Lo, 7 mi W Dong Ha (USNM). WESTERN CAROLINE ISLANDS. Palau-Babelthaup (BMHH). Yap (BMNH). COUNTRY NOT DETERMINED: Borneo. (BMNH)(USNM). New Guinea—country not found. Fenichel (MCZ). Lao (MCZ).

Relationships of *Celaenephes* Schmidt-Göbel

The authors have not been able to achieve consensus about the relationships of *Celaenephes*. Two of us (D.S. and G.E.B.) believe that *Celaenephes* is not closely related to other extant genera of lebiines. One of us (R.B.M.) believes that this genus is related to *Cymindis* (*sensu stricto*) Latreille. Because of the nature of a hierarchical system of classification, such differences of opinion are not easily accommodated: the former hypothesis leads to placing *Celaenephes* in a monobasic subtribe, as Habu (1982) has done. The latter hypothesis, in a phylogenetic system of classification, requires inclusion of *Celaenephes* in the subtribe Cymindina. Evidence for each hypothesis follows, though the hypothesis favored by Shpeley and Ball prevails in formally classifying *Celaenephes*.

CELAENEPHES AND THE SUBTRIBE CELAENEPHINA

Elements of the defining combination of character states of the subtribe Celaenephina are assessed below in terms of those states of lebiine subtribes in which the genus *Celaenephes* has previously been included (Pericalina, Cymindina, and Dromiina), using as an out-group the tribe Platynini. Choice of platynines as out-group is based on their generally more plesiotypic structures and on the likelihood of a close phylogenetic relationship between Platynini and Lebiini (Liebherr, 1983).

CHARACTERS AND CHARACTER STATES

Eighteen characters, diagnostic for lebiine subtribes, are used in assessing relationships. States of these characters are classified phylogenetically, and taxa are compared in terms of synapotypic states. The sequence of characters in the presentation is that in which their apotypic states would appear in a reconstructed phylogeny of the Lebiini.

The basis of classification of each state as plesiotypic (ancestral) or apotypic (derived) is out-group comparison, as explained by Wiley (1981: 139–146) and Watrous and Wheeler (1981).

01. Abdominal tergum VIII, lateral margin.—Two states: plesiotypic, lateral margins rounded, not produced as lobes (Fig. 24); apotypic, lateral margins produced as lobes (Figs. 7, 25, and 26). Each lobe is associated with the opening of a duct of the paired pygidial defense glands.

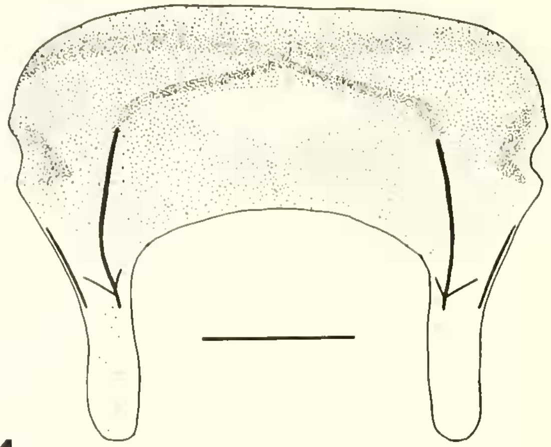
02. Mandibles, secretory groove.—Three states: plesiotypic, absent; two apotypic states—a, well developed, almost as long as terebra (Figs. 15B, 16B, and 17A, B); b, much shorter (*cf.* Ball and Hilchie, 1983: 140, figs. 41C, D, and 43C, D). Such grooves are widely distributed among lebiine genera, though in many, the grooves are lacking. We interpret this as a loss, based on phylogenetic analysis using celaenephines and pericalines as functional out-groups (Watrous and Wheeler, 1981) in relation to the generally more derived cymindines and dromiines.

03. Antennomeres 4–11, sensory pits.—Two states: plesiotypic, absent; apotypic, present (Figs. 12A, B). These pits and their associated sense organs are known among carabids only in adult lebiines of *Celaenephes* and of the seemingly unrelated genera *Euproctinus* Leng and Mutchler, and *Parena* Motschulsky (both genera tentatively assigned to subtribe Metallicina [see Basilewsky, 1984: 542–543, for a diagnosis of the group]).

04. Left mandible, anterior retinacular tooth.—Two states: plesiotypic, absent; apotypic, present (Figs. 15A, B).

05. Abdominal sternum X, extent of sclerotization.—Two states: plesiotypic, principally membranous; apotypic, principally sclerotized (Fig. 10). Although sternum X was no doubt sclerotized in ancestral carabids, this sclerotization is reduced in the more derived groups, including platynines. The condition in *Celaenephes* is interpreted as a reversal to a seeming plesiotypic condition. However, the sclerotization is in the form of a spicule rather than more or less rectangular, as a plesiotypic sclerite would have been (i.e., the ventral counter-part of the rectangular tergum X, Fig. 9).

06. Left mandible, terebral tooth.—Two states: plesiotypic, present; apotypic, absent (Figs. 15A, B). Although the Pericalina and Dromiina are classified as plesiotypic for this character, this is only because at least some members of each of these subtribes exhibit a terebral tooth. The tooth is lacking from many mem-



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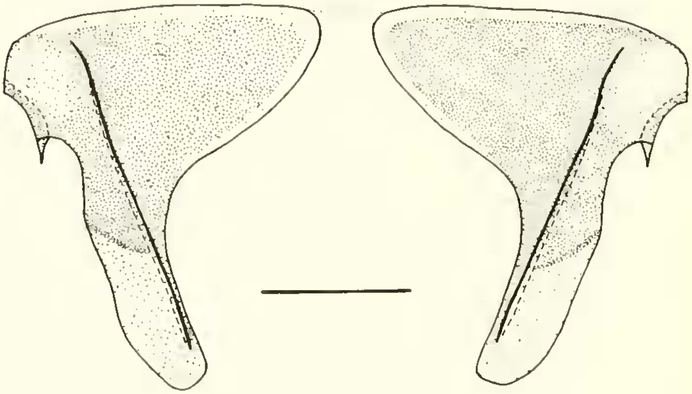

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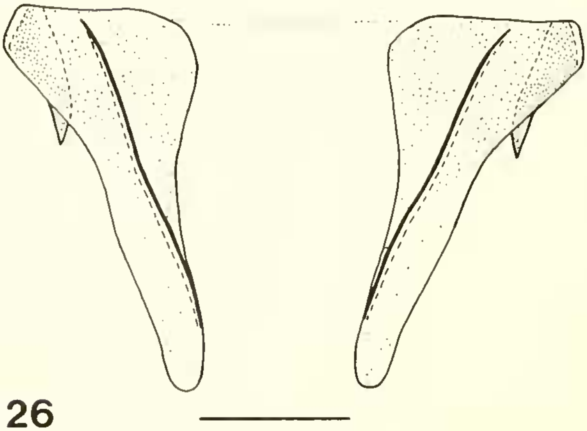

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Figs. 24–26. Line drawings of tergum VIII of selected platynine and lebiine females. 24, *Platynus decentis* Say. 25, *Cymindis chevrolati* Dejean. 26, *Lebia urania* Bates. (Scale bars = 0.50 mm.)

bers of these groups, and the absence is interpreted as a loss following origin of each subtribe.

07. Elytron, apical microsetae.—Two states: plesiotypic, absent; apotypic, present.

08. Elytron, form of apex.—Two states: plesiotypic, tapered preapically, apex a blunt point; apotypic, truncate (Figs. 2, 3, and 18B).

09. Ovipositor, stylomere 2, length of nematoid setae.—Four states: plesiotypic, length normal, about 10–50 per cent of length of stylomere 2 (*cf.* Ball and Hilchie, 1983: 100, figs. 2A–C); three apotypic states—a, hypertrophied, as long or longer than stylomere 2 (Figs. 21A–C); b, reduced, about 5 per cent of length of stylomere 2 (*loc. cit.*, 142, fig. 10B); c., absent.

10. Abdominal tergum VIII, extent of sclerotization of dorsal surface.—Four states: plesiotypic, sclerotization continuous medially at anterior margin, desclerotized more posteriorly in a narrow longitudinal or transverse band (Fig. 24); three apotypic states—a, hypertrophied, tergum VIII completely sclerotized medially (Fig. 7); b, medial desclerotized area more extensive, though lateral sclerotized areas with extensive medial projection (Fig. 25); c, medial desclerotized area still more extensive, sclerotized areas reduced to narrow lateral strips (Fig. 26).

The pattern for this character parallels that of sternum X, in that re-sclerotization seems to have taken place in celaenephine adults.

11. Anterior coxal cavities.—Two states: plesiotypic, uniperforate; apotypic, biperforate. The derived character state has been regarded as diagnostic of lebiines by most authors who have written about carabid classification (see, for example, Ball and Hilchie, 1983: 108). Thus, it was something of a surprise to find that adults of the supposedly lebiine genus *Celaenephes* are characterized by uniperforate cavities. It was even more surprising to find both uniperforate and biperforate anterior coxal cavities among the genera of Cymindina (coxal cavities biperforate in *Trichis* Klug and *Hystrichopus* Boheman; uniperforate in *Cymindis* [subgenera *Pinacodera* Schaum and *Cymindis sensu stricto*]). Withough a thorough examination of the distribution of states of this character among lebiines, it is impossible to determine unequivocally how to classify the former. Because of the many plesiotypic states exhibited by *Celaenephes* adults, it seems reasonable to hypothesize that the uniperforate cavities of its adults were inherited from the common ancestor of the lebiines, whereas for the subgenera of *Cymindis* (moderately highly derived taxa within a moderately highly derived subtribe) the coxal cavities have probably become uniperforate secondarily, the result of an evolutionary reversal. In fact, however, the uniperforate condition is listed in Table 1 as only plesiotypic.

12. Relative size of right paramere.—Two states: plesiotypic, right paramere about as long as left (see Habu, 1967: 252, fig. 489); apotypic, right paramere much smaller than left, adnate or not to basal part of median lobe.

13. Male genitalia, median lobe, sclerotization of dorsal surface.—Two states: plesiotypic, dorsum almost completely membranous (Figs. 5A and 6A); apotypic, much of dorsal surface sclerotized, membranous portion near preapical orifice, only.

14. Elytron, umbilical series, penultimate puncture.—Two states: plesiotypic, in line with adjacent punctures (Fig. 18B); apotypic, displaced laterally (*cf.* Ball and Hilchie, 1983: 119, fig. 27B).

15. Head: suborbital setae.—Two states: plesiotypic, absent; apotypic, present.

16. Ovipositor, stylomere 2, number of dorsal ensiform setae.—Three states: plesiotypic, two (or more) (Fig. 21B); two apotypic states—a, one; b, zero.

17. Ovipositor, form of stylomere 2.—Two states: plesiotypic, more or less falcate, dorsal margin curved (Fig. 21B); apotypic, not falcate (*cf.* Ball and Hilchie, 1983: 188, figs. 121A, 122A, 123A).

18. Left mandible, premolar tooth.—Two states: plesiotypic, tooth present; apotypic, tooth absent.

Distribution of Character States

Basilewsky (1984: 528) stated that *Celaenephes* is a platynine. Although his conclusion is based on symplesiotypy (characters 12, 13, 16, and 17) and is thus not valid in a phylogenetic system, we concede that the evidence for including *Celaenephes* in the Lebiini based on synapotypy (characters 01 and 02) is not very strong. (Added to the synapotypic features, we note the mid-tibial notches and sensory antennal pits of *Celaenephes,* which, being convergent with some lebiines, might be taken as slight evidence of an underlying similar genetic potential, and hence relationship). Furthermore, the Platynini, as generally diagnosed in terms of adult features, seems to lack synapotypic character states, and so might be a paraphyletic assemblage, one line of which might be the sister group of the Lebiini. Be that as it may, acquisition of the full complement of apotypic features of the Lebiini was likely additive, with new states developing and being incorporated one by one. Thus, a platynine lineage with the features of *Celaenephes* could very well have been the founder stock of the Lebiini, and we believe that this is so. Consequently, we regard *Celaenephes* as a lebiine, without denying its platynine affinities.

The distribution of apotypic character states (Table 1) shows that *Celaenephes* is markedly different from the groups of lebiines with which it has been associated. The characters with apotypic states in *Celaenephes* are over-represented in this study, however, simply because attention is focused on this group. Nonetheless, *Celaenephes* is basically a primitive lineage as shown by the states of characters 11–18. The long secretory groove of the mandibles is also interpreted as plesiotypic within lebiines, though it is apotypic compared to platynines. All features considered, Habu (1982) was well justified in deciding to place *Celaenephes* in a subtribe remote from the Dromiina, and removed from other lebiine subtribes as well.

Relationships of the Celaenephina

To establish fully our conclusion that the subtribe Celaenephina exhibits a predominantly plesiotypic combination of character states within its tribe, it might seem necessary to undertake a phylogenetic analysis of the tribe Lebiini. We cannot do so now, though we can offer reference to some published evidence which we think offers adequate support for our conclusion. The single best source is Basilewsky's (1984) remarkable paper that provides figures of the stylomeres for all the groups with which he was familiar (and this includes almost all of the known lebiine stocks), plus reference to other character systems; nonetheless, we do not endorse fully his classification nor his basically typological methods for establishing it. His presentation shows that all of the lebiine groups not referred to in